MIDWAY

A Magazine of Discovery in the Arts and Sciences

THE EDICTS OF ASOKA

TRANSLATED BY N. A. NIKAM AND RICHARD McKEON

People Are Different

WESTON LA BARRE

In America All Women Are Ladies

FRANCIS LIEBER

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The gateway of the Great Stupa at Sanchi, the site of the most extensive Buddhist remains now known in India. They date from the time of Aśoka, and may have been built by him or his son, Mahendra.

THE

EDICTS OF ASOKA

EDITED AND TRANSLATED BY

N. A. NIKAM and RICHARD McKEON

In the second century B.C. a powerful Indian emperor had a change of heart. He abandoned the use of force and appealed instead to the moral values of his subjects. Carved on rocks and pillars, his edicts still stand as testimonies to his wisdom.

Aśoka, one of the greatest of the Indian emperors (ca. 274–232 B.C.), was the grandson of Chandragupta Maurya, founder of the Mauryan dynasty. Paucity of historical records makes it difficult to reconstruct the careers and personalities of even the most prominent figures of Indian history. The establishment of Chandragupta's empire (322 B.C.) coincides with the death of Alexander the Great (323 B.C.), and fragments of an account of Chandragupta's court and administration written by Megathenes, ambassador of Seleucus, survive in the writings of Greek and Roman historians. The earliest accounts of Aśoka's

reign, on the contrary, are found in legends recorded by Buddhist chroniclers in Ceylon and India.

Aśoka, however, left a record which he hoped would endure forever. It is a record inscribed on stone, not as a monument to himself or to commemorate his exploits, but as a record of moral law, of the experience which led him to promulgate it, and the meditations which yield his interpretation and instruction. He refers to the inscriptions sometimes as records of morality (*Dharma-lipi*), sometimes as proclamations of morality (*Dharma-śrāvaṇi*), and he expressed the hope that they would endure in order to provide inspiration and guidance to his descendants and to the people.

The records have survived. They did not, however, serve as a guide to Aśoka's descendants, since the Mauryan dynasty ended about fifty years after his death; nor did they serve as a guide to conduct, since they became indecipherable when Prākrit ceased to be the spoken dialect of the people, and early traditions concerning Aśoka have little bearing on the contents of the inscriptions.

The two famous Chinese Buddhist pilgrims who visited India, Fa Hien (A.D. 401–10) and Hiuen Tsang (or Yuan Chwang —A.D. 629–45), describe the remains of Aśoka's palace and other buildings, but their accounts are colored by the legends and indicate no familiarity with the Edicts. Fa Hien saw six pillars. Hiuen Tsang mentions fifteen; some few—four or five—have been conjecturally identified with existing pillars; some have disappeared. Aśoka erected both uninscribed and inscribed pillars, and only two of the inscribed pillars now known have been positively identified with those reported by Hiuen Tsang. The pillars erected at Meerut and Tōprā were transported to Delhi by Sultan Diruz Shah (1351–88). The pillar erected at Kauśāmbī was transported to Allahabad, possibly by Akbar. For the most part, however, with the change of population centers

and the encroachment of the jungle, the inscriptions disappeared, and their very location was forgotten.

Knowledge of the Edicts of Aśoka is consequently a recent acquisition. The first modern account of a pillar inscription was set down by Father Tieffenthaler, a Roman Catholic priest who inspected fragments of the Meerut pillar at Delhi in 1756. The Aśoka script was deciphered for the first time by James Prinsep in 1837. Since that time the inscriptions have been rediscovered, published, and interpreted. In a sense, the character of the man who issued the Edict emerges clearly and sharply: wisdom combined with practical shrewdness; tolerance—unique in his time and unsurpassed by later potentates of like power—combined with moral discrimination and administrative judgment; a concern with the material welfare and happiness of his people combined with a desire to improve their moral outlook and to turn their attention away from the pursuit of material possessions, prestige, and pleasure; a sense of the kinship of all men and a respect for all living creatures combined with a conviction that men must pursue their ends in different ways and peoples must live in peace with each other. Nonetheless, the very uniqueness of the Edicts has tempted interpreters to stress aspects and to draw analogies which make Aśoka seem another religious missionary, sectarian prince, empire-builder and administrator, or philosopher-king. His differences from each of these prototypes are no less important than the similarities that have been observed.

The early legends of Aśoka's career have continued to influence the interpretation of the Edicts, in spite of the fact that the incidents they recount and the character they construct are for the most part inconsistent with the Edicts and without independent historical evidence or plausibility. They tell a tale of the conversion to Buddhism of a cruel young tyrant, guilty of unspeakable atrocities, including the murder of ninety-nine

of his one hundred brothers, and his subsequent zeal for the spread of Buddhism, both in India and in Ceylon, as a result of which he ceased to be known as Aśoka the Wicked and was called instead the king of Dharma (*Dharmarāja*). The edicts tell of Aśoka's conversion and his becoming a lay disciple; but he appears less as the missionary for one faith than as the exponent of tolerance for all faiths, and his zeal for Buddhism takes the form of calling the attention of Buddhists to the importance of studying Dharma and of avoiding disruptions.

Aśoka's career turns on one important event, his only military campaign—the short Kalinga war in which he conquered a neighboring people. He records his profound emotion in reaction to the cruelties of this war and his "change of heart." According to the testimony of the Edicts, the change was manifested in his personal life, in the operation of the royal household, and in the organization of governmental administration. The Edicts, which are a consequence as well as an expression of the change, relate it in all its dimensions to the idea of Dharma, of morality—Dharma provides a code of personal conduct, a bond of human relations and political justice, and a principle of international relations, and Dharma turns the lives of men away from evil deeds, mutual intolerance, and armed conflict.

In the new career on which Aśoka embarked, the religious, political, and moral motivations and objectives are inseparably interrelated—religious observance and political administration are transformed by application of moral principles, and ethics is made concrete and relevant to everyday action and feeling. Aśoka's conversion to Buddhism, or at least his increase in zeal as a lay disciple, coincided approximately with the events of the Kaliṅga war. His mission became study of Dharma, action according to Dharma, and inculcation of Dharma. . . .

Aśoka sums up his teaching in a single word, "Dharma."

His Edicts make it clear that he conceived his mission to consist in defining, publishing, and propagating Dharma; and the strength and originality of his teaching are underlined by the meaning he gave to that ambiguous term. "Dharma" means the insights and precepts of religion and piety; it also means the principles and prescriptions of ethics and morality. The basic problems of religion and morality are illustrated vividly in the differences among the interpretations that have been made of his teachings: it is sometimes held that Aśoka's conception of Dharma is essentially Hindu, with a Buddhist tinge; sometimes that it is basically Buddhist, in reaction to Brahmanic ideas; sometimes that it is a generalization of morality, freed from sectarian limitations and that, consequently, both translations of Dharma—the "laws of piety" and the "laws of morality"—have been held to be misleading. This is a controversy which belies the basic teachings of the Edicts. With remarkable clarity, Aśoka recognized the interplay of the various dimensions of the moral life: it reflects a man's duties as determined by his station in life; it reflects a basic order in the universe and a truth discerned in that order; it is a bond uniting people in their associations in families, communities, religions, and nations; it is a fundamental insight, differently expressed in different cultures and religions, which serves as a basis for mutual understanding and peace; it is a guide to action and to self-realization and happiness; it is achieved by action, advanced by instruction, and protected by sanctions, and in turn it provides a basis for policy, education, and justice; it is discovered by self-scrutiny, meditation, and conversion, and it entails renunciation of whatever is inconsistent with it.

The Hindu conception of Dharma concentrated on a rule of life, adapted to the caste and station of each man, by which his whole duty—moral, social, and religious—was determined.

Each caste had its own Dharma, but Dharma was also the moral order and the truth, *ṛta* or *satya*, transcending the gods and preserved by them. The Buddhist conception of Dharma turned from the theological and metaphysical aspects of Dharma, as absolute truth and highest reality, to concentrate on its operation in the laws of nature and the relations of men. Dharma is the King of Kings, and it is manifested in the properties, ground, and cause of a thing or a person. Aśoka's conception of Dharma separates it from caste distinctions, religious ceremonials, and theological dogmas; his instruction in Dharma denudes it also of the anagogic interpretations of the career of man developed in Buddhist doctrines of rebirth, the four truths about sorrow, and the ways of deliverance in Nirvana. His Dharma depends on insight and change of heart; it has its applications in individual actions and in human relations; it finds its objective in happiness in this world and in heaven.

Aśoka attributes his own interest in Dharma to repentance for the violence and cruelty of the Kaliṅga war. The change of heart brought about by his reflections on war inspired him to the promulgation of his Edicts by providing an insight for moral reform. His interest throughout is practical in its orientation. He devoted himself to study of Dharma, to action according to Dharma, and to inculcation of Dharma, but the three are inseparable—the study of Dharma translates Dharma into concrete action; action according to Dharma provides examples to guide inculcation; inculcation of Dharma, although it depends on instruction, supervision, administration, and institutions, is achieved finally only by meditation and study.

The study of Dharma is a study of attitudes and motives which transforms the customary principles of action. The change of heart brought about by Aśoka's reflections on war provided him with the insight which he employed in all his

moral reforms. The moral equivalent for war is found when the impulse to conquest by violence yields to the desire for conquest by morality (*Dharma-vijaya*). Evil actions and good actions are both transformed in the process. Liberality, thus, is a virtue, but all other gifts are unimportant when compared to the gift of morality (*Dharma-dāna*). The gift of morality, in turn, suggests a basis for the distribution of riches based in morality (*Dharma-saṁvibhāga*), for acquaintance with men based in morality (*Dharma-saṁstava*), and for kinship among men based in morality (*Dharma-saṁbandha*). Sacraments, in like fashion, have their place in religion, but the sacrament of Dharma (*Dharma-maṅgala*) makes all other rites and ceremonials unimportant. Pleasure is a legitimate motive to action, but true pleasure is pleasure in morality (*Dharma-rati*), and Aśoka took pleasure in abandoning the customary royal pleasure tours for moral tours (*Dharma-yātrās*). The foundation of law and the guidance of its administration must be found in morality, and therefore Aśoka transformed his system of administration by instituting a new category of high officials charged with the promulgation and supervision of morality (*Dharma-mahāmātras*). Their function was to lead people to attachment to morality and to action according to it as well as to increase the morality (*Dharma-vṛddhi*) of people already devoted to morality (*Dharma-yukta*). People devoted to morality (*Dharma-yukta*) include those inclined to morality (*Dharma-niśrita*), those established in morality (*Dharma-adhiṣṭhita*), and those duly devoted to charity (*dānasaṁyukta*). As one reads the Edicts, the linguistic mark of Aśoka's study of morality becomes apparent in the combination of the word "Dharma" with another word signifying an activity or an attitude which defines Dharma as applied to act or motive and which is itself transformed in that definition. Aśoka's statement of the three dimensions of his purpose uses the

same device to express his devotion to study of Dharma (*Dharma-pālana*), to action according to Dharma (*Dharma-karma*), and to inculcation of Dharma (*Dharma-anuśiṣṭi*).

The study of Dharma is not only the basis of concrete action according to Dharma; it is also an action. It is action affecting the principles of action. Study of Dharma achieves the purification of one's fundamental beliefs by returning one's scrutiny to oneself, to self-examination which is the basis of moral action, and to self-exertion which is the means of moral progress. Such knowledge of self leads to recognition of the diversity of ways by which others come to their interpretations of Dharma, and that recognition gives tolerance and the sanctity of life the force of principles. Respect for others is both a consequence and a source of purification of one's own aspirations and beliefs. The conquest of Dharma provides insight into true glory. The gift of Dharma gives meaning to material possessions and material gifts in the light of the kinship of mankind. Devotion to Dharma gives direction to all law and furnishes means to relate physical welfare to happiness. Granted insight and devotion to morality, Dharma can be defined in concrete terms appropriate to the actions of a man and the relations among men. Dharma, in the individual, consists of few sins and many good deeds, of avoidance of evil and passions—of anger, cruelty, rage, pride, and envy—and of cultivation of kindness, liberality, truthfulness, inner and outer purity, gentleness, saintliness, moderation in spending money and acquiring possessions, self-control, compassion, gratitude, and devotion. These are all manifestations of attachment to morality and love of it. Dharma, in human relations, takes the form of a moral code which is repeated in several of the Edicts: obedience to mother, father, elders, teachers, and those in authority; respect for teachers; proper treatment for members of the priestly and ascetic orders, rela-

tives, slaves and servants, the poor and unfortunate, friends, acquaintances, and neighbors; liberality to ascetics, friends, companions, relatives, and the aged; abstention from slaughter of living creatures.

The study of morality and action according to morality take their concrete form for Aśoka himself in the inculcation of morality. There are only two means of inculcating morality —prescriptions and meditation—and prescriptions are ineffective without insight into oneself and the consequences of one's action, without the turning about in one's basic motivations which gives meaning to remorse and conversion, and without meditation on oneself which is the foundation of understanding and purpose. Aśoka's inculcation of morality is a sensitive and shrewd combination of inspiration and constraint, of ideal example and administrative sanction. He instituted officers of morality, charged with instruction, with the imposition of penalties, and with the distribution of honors and gifts; and he included in the duties of other officials the supervision of morality. Several of the Edicts take the form of instructions to his officials in which he tells them, in pragmatic language, that he expects what he conceives to be good to be translated into action and to be put into effect by appropriate measures. He proclaims his adherence to Buddhism, but he draws up his own list of Buddhist texts which treat of morality and instructs monks and nuns to study them. He proclaims tolerance for all faiths, regards all men as his children, and seeks understanding with other countries, near and far, based on confidence and morality. He makes provision for the health and well-being of his people, introduces judicial reforms, provides amenities for the performance of religious observances. He proclaims his readiness to pardon offenses against himself, but he specifies that he has power of retribution if the ways of the offenders are not improved or the offense is unpardon-

able; he proclaims presciiptions, policies, and penalties; he recognizes the importance of insight, and he is confident that his example will be more effective than his power and will transcend the limitations of time and the confines of his empire.

The Edicts of Aśoka form part of a large body of literature, drawn from all cultures, which seeks power not in domination of men or accumulation of possessions but in conquest of self, in understanding of others, and in contemplation of truths within the scope of reason and goods within the scope of action. It finds expression sometimes in art and poetry; sometimes in religious meditation, philosophical reflection, or humanistic or scientific inquiry; sometimes in the labors by which the mechanisms and materials required for human welfare are developed and controlled. It sometimes erects a city of God, a republic of letters, a commonwealth of mankind, or an academy of science removed from the rivalries and vices of the city of men. It sometimes lays down precepts to guide the sage or the saint, the humble man or the sinner, and to make him immune to changes of fortune and threats of power. It sometimes provides insights and motivations by which human communities are transformed and human beings are liberated for the realization of potentialities unsuspected and inaccessible in other societies.

The classics of this literature may take on a new importance and a new power in the world today. They may recall us to the ideal of tolerance of divergent opinions and open up the way to build communities which take their strength from diversity and freedom and which recognize the possibilities of a world community based on a like tolerance and diversity and guided by a sense of the responsibilities imposed by the present world situation. The progress of communication has made unavoidable world community of some kind; insight

into the values of tolerance, reason, love, and sensitivity derived from the reflections of poets, saints, philosophers, and statesmen will provide means by which to make it a genuine community based on genuine communication. Such insight will provide no weapons for the struggle for power which is also a consequence of progress of communication; but struggles for power are seldom won by either opponent—they are often forgotten together with their protagonists, or recorded as a memorial to what was destroyed. Their causes are removed by peeace and order and understanding. . . .

Since Dharma is a fundamental concept in Buddhism, this concern for Dharma has been interpreted—in the spirit of the legends, which contain no account of the Kaliṅga war and its effect but do set forth the efforts of Aśoka to spread Buddhism and the missions of his son Mahendra and his grandson Sumana to Ceylon—as a missionary zeal for Buddhism. However, Dharma was also a fundamental idea of Hinduism and of the other sects of India. Far from restricting Dharma to the tenets and practices of a single religion, Aśoka asserts in Rock Edict XII that Dharma is cultivated in all religions and sects, and he seeks to advance Dharma in all men whatever their religious affiliations; and, true to this purpose, he instructs Buddhists, in Minor Rock Edict III, to pay more attention to Buddhist texts on Dharma. Rock Edict VII presents the ideal of tolerant harmony among all the sects of his dominion. The newly created officers of Dharma were charged to attend to the welfare of all his subjects, including special functions in each of the sects, Hindu, Ājīvika, and Jain as well as Buddhist. Finally, foreign missions, which were dispatched not only to Ceylon but to the five Hellenistic Greek kingdoms ranging from Syria to Macedonia, are mentioned in two Edicts—Rock Edict XIII records that these peoples received instruction in Dharma, Rock Edict II that they received medical services.

Dharma and welfare are closely connected in the Edicts, and the tone and spirit of the Edicts suggests that the measures referred to were designed to improve the material and spiritual conditions of the peoples of neighboring states rather than to convert them to Buddhism. The cultivation of Dharma was to emphasize morality in religion, in man's relations with the gods, in his conception of sacraments, in his relations with other men, in his charity. One short inscription in Greek and Aramaic—an edict prohibiting the slaughter of animals similar in purport to Rock Edict I—has recently been found at Kandahar in Afghanistan. Kandahar was within Aśoka's empire, part of the territory ceded to his grandfather by Seleucus Nicator, but the inscription lends plausibility to Aśoka's claim to influence in the Hellenistic Greek kingdoms and illustrates vividly the extent to which his instructions were carried out to inscribe the Edicts wherever possible.

In much the same fashion, Aśoka used the idea of Dharma to reorganize the administration of the empire. His accession to the throne was not unopposed, and the empire was vast in extent and divided into many sects, classes, and castes—referred to in the Edicts in expressions like "ascetics and householders" and "rich and poor." Indian rulers were absolute sovereigns limited by social disorder, political intrigue, and military rivalry. Aśoka inherited a system of administration from his grandfather and father. The Edicts were one means by which he laid down fundamental policies interpreting the laws. Subordinate officials were given discretion in their own districts within a system which provided for constant inspection and supervision. A special class of officers was specifically charged with morality or Dharma, and provision was made against unjust imprisonment and undue torture and for appeal before the execution of sentence. The functions of the officials were extended to include provision of medical aid, roads, watering sheds for man and

beast, shade trees, and rest houses. The whole political organization was made subsidiary to moral law in a concrete translation of the law into specific forms of human and social relations.

The focus of Aśoka's activities was therefore moral. The morality did not consist in the preachment of an ideal or in the prescriptions of a code. Aśoka taught that the essence of law, religious and political, was insight into one's self and respect for others. The method was instruction, and, although instruction depends on prescriptions as well as meditation, he was convinced that prescription was valueless, and he placed all his confidence in what he called meditation. Meditation as he conceived it was not theoretic speculation or mystical contemplation—it manifested itself in one's relations to others and in one's inner attitude and outer aspirations. Its effect was a conversion toward other desires and ideals under the influence of a broader and richer conception of human kinship and dignity, which was to lessen tensions, fears, and covetousness. It adumbrated a new idea of responsibility in which tolerance for others is not indifference but an influence toward improvement. It involves an insight into morality applied in political and social relations which stands in striking contrast to the moral confidence which judges others by one's own standards and the moralizing deception which preaches what no one practices. History provides no information concerning how the program worked out in the administration of Aśoka, but the basic ideas and practices set forth in the Edicts take on a new meaning and relevance in a time like ours when the problems of individuals and of nations are once again fundamentally moral problems.

AGAINST RELIGIOUS INTOLERANCE AND DISCRIMINATION WITHIN THE COMMUNITY

{ *Rock Edict VII* }

King Priyadarśi [meaning "The Benevolent One." (Aśoka

never used his own name in the edicts)] wishes members of all faiths to live everywhere in his kingdom.

For they all seek mastery of the senses and purity of mind. Men are different in their inclinations and passions, however, and they may perform the whole of their duties or only part.

Even if one is not able to make lavish gifts, mastery of the senses, purity of mind, gratitude, and steadfast devotion are commendable and essential.

⊰ *Rock Edict XII* ⊱

King Priyadarśī honors men of all faiths, members of religious orders and laymen alike, with gifts and various marks of esteem. Yet he does not value either gifts or honors as much as growth in the qualities essential to religion in men of all faiths.

This growth may take many forms, but its root is in guarding one's speech to avoid extolling one's own faith and disparaging the faith of others improperly or, when the occasion is appropriate, immoderately.

The faiths of others all deserve to be honored for one reason or another. By honoring them, one exalts one's own faith and at the same time performs a service to the faith of others. By acting otherwise, one injures one's own faith and also does disservice to that of others. For, if a man extols his own faith and disparages another because of devotion to his own and because he wants to glorify it, he seriously injures his own faith.

Therefore, concord alone is commendable, for through concord men may learn and respect the conception of Dharma accepted by others.

King Priyadarśi desires men of all faiths to know each other's doctrines and to acquire sound doctrines. Those who are attached to their particular faiths should be told that King Priyadarśī does not value gifts or honors as much as growth in the qualities essential to religion in men of all faiths.

Many officials are assigned to tasks bearing on this purpose—the officers in charge of spreading Dharma, the superintendents of women in the royal household, the inspectors of cattle and pasture lands, and other officials.

The objective of these measures is the promotion of each man's particular faith and the glorification of Dharma.

AGAINST AGGRESSION AND TENSION BETWEEN STATES

{ Kaliṅga Edict II }

King Priyadarśī says:

I command that the following instructions be communicated to my officials at Samāpā:

Whenever something right comes to my attention, I want it put into practice and I want effective means devised to achieve it. My principal means to do this is to transmit my instructions to you.

All men are my children. Just as I seek the welfare and happiness of my own children in this world and the next, I seek the same things for all men.

Unconquered peoples along the borders of my dominions may wonder what my disposition is toward them. My only wish with respect to them is that they should not fear me, but trust me; that they should expect only happiness from me, not misery; that they should understand further that I will forgive them for offenses which can be forgiven; that they should be induced by my example to practice Dharma; and that they should attain happiness in this world and the next.

I transmit these instructions to you in order to discharge my debt [to them] by instructing you and making known to you my will and my unshakable resolution and commitment. You must perform your duties in this way and establish their

confidence in the King, assuring them that he is like a father to them, that he loves them as he loves himself, and that they are like his own children.

Having instructed you and informed you of my will and my unshakable resolution and commitment, I will appoint officials to carry out this program in all the provinces. You are able to inspire the border peoples with confidence in me and to advance their welfare and happiness in this world and the next. By doing so, you will also attain heaven and help me discharge my debts to the people.

This edict has been inscribed here so that my officials will work at all times to inspire the peoples of neighboring countries with confidence in me and to induce them to practice Dharma.

This edict must be proclaimed every four months [at the beginning of the three seasons—hot, rainy, and cold] on Tiṣya days [i.e., when the moon is in the constellation containing Tiṣya, Sirius]; it may also be proclaimed in the intervals between those days; and on appropriate occasions it may be read to individuals.

By doing this, you will be carrying out my commands.

PUBLIC ADMINISTRATION: THE PROMULGATION OF MORALITY AND THE ADMINISTRATION OF JUSTICE

⊰ *Rock Edict III* ⊱

King Priyadarśī says:

Twelve years after my coronation I ordered the following:

Everywhere in my dominions local, provincial, and state officials shall make a tour of their districts every five years to proclaim the following precepts of Dharma as well as to transact other business:

Obedience to mother and father; liberality to friends, acquaintances, relatives, priests, and ascetics; abstention from

killing living creatures; and moderation in spending money and acquiring possession are all meritorious.

The Council shall direct local officials concerning the execution of these orders in accordance with my instruction.

{ *Rock Edict V* }

In the past there were no officers charged with spreading Dharma. I created these posts in the thirteenth year of my reign.

These officers are commissioned to work with all sects in establishing and promoting Dharma, in seeing to the welfare and happiness of all those devoted to Dharma, among the Yōnas, Kambōjas, Gandhāras, Rāṣṭrikas, Pitinikas, and other peoples living on the western borders of my kingdom. They are commissioned to work among the soldiers and their chiefs, the ascetics and householders, the poor and the aged, to secure the welfare and happiness and release from imprisonment of those devoted to Dharma. They are also commissioned to work among prisoners to distribute money to those who have many children, to secure the release of those who were instigated to crime by others, and to pardon those who are very aged.

They have been assigned everywhere—here [at Pāṭaliputra], in all the provincial towns, and in the harems of my brothers and sisters and other relatives. These officers in charge of spreading Dharma are at work everywhere in my dominions among people devoted to Dharma, whether they are only inclined to Dharma or established in Dharma or duly devoted to charity.

I have commanded this edict on Dharma to be inscribed so that it may last forever and so that my descendants may conform to it.

{ *Kaliṅga Edict I* }

King Priyadarśī orders the following instructions to be transmitted to his officials at Tosalī:

Whenever something right comes to my attention, I want it put into practice and I want effective means devised to achieve it. My principal means to do this is to transmit my instructions to you. For I have placed you in charge of thousands of people to obtain their affection for me.

All men are my children. Just as I seek the welfare and happiness of my own children in this world and the next, I seek the same things for all men. You do not understand this desire of mine fully. Some of you may understand it, but even those grasp it only partially, not fully. However elevated your position, you must give it your attention.

Sometimes in the administration of justice a person will suffer imprisonment or torture. When this happens, he sometimes dies accidentally, and many other people suffer because of this.

In such circumstances, you must try to follow the middle path [that is, justice or moderation]. Envy, anger, cruelty, impatience, lack of application, laziness, and fatigue interfere with the attainment of this middle path. Therefore, each of you should try to be sure that you are not possessed by these passions.

The key to success in this endeavor is not to become angry and not to hurry. The tired administrator will not advance, but you should move, advance, and progress. Your supervisors must tell you,"Put all your effort to carrying out the duties assigned to you by the King. Such and such are the instructions of the Beloved of the Gods."

The observance of this injunction will produce great good; failure to observe it will produce great harm. For, if you fail to observe it, you will attain neither heaven nor the King's favor. The reason for this extreme thought is that a double gain is procured by observing this duty, for by carrying it out properly you will gain heaven and also satisfy your obligations to me.

This edict must be read to all on every Tiṣya day. It may be read even to individuals on suitable occasions at other times. If you do this, you will be able to carry out your duty.

This edict has been inscribed here to remind the judicial officers in this city to try at all times to avoid unjust imprisonment or unjust torture. To the same end I shall send out every five years an official who will not be harsh or cruel but gentle, and his assignment will be to see that the judicial officers are following my instructions. Moreover, the prince who governs the city of Ujjayinī will send out the same kind of officials at least every three years. An official will be sent out from Takṣaśilā also. These officials will not neglect their own duties, but they will also check to see whether the local judicial officers are carrying out the King's instructions.

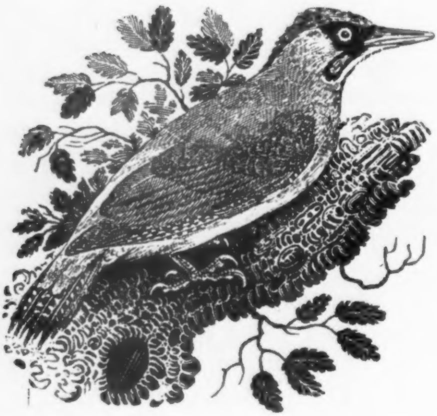
MEDICAL AID AND WELFARE

Pillar Edict VII

King Priyadarśī says:

I have ordered banyan trees to be planted along the roads to give shade to men and animals. I have ordered mango groves to be planted. I have ordered wells to be dug every half-kos [about a half-mile], and I have ordered rest houses built. I have had many watering stations built for the convenience of men and animals.

These are trifling comforts. For the people have received various facilities from previous kings as well as from me. But I have done what I have primarily in order that the people may follow the path of Dharma with faith and devotion.



COMPARATIVE ANATOMY OF THE AVIARY BRAIN

By Stanley S. Cobb

Why do birds migrate? Do they have a sense of smell? How do they guide themselves on their long flights? This famous neuropsychiatrist considers these and many other questions.

Birds have two conspicuous characteristics: one is their specialization in form and function, the other is the great extent to which instinct governs their behavior. Within a given species birds are much alike; similarity in anatomy and behavior is the rule. Some birds have remarkable learning ability and develop considerable individuality, but this is more conspicuous in mammals. It is generally accepted that the cerebral cortex of man is the organ essential for the discriminative adaptations that make intelligent behavior possible. (Throughout this paper "intelligence" will be defined as the ability to adapt effectively to new and varying environmental situations.) There is no satisfactory evidence indicating which structure in a bird's brain subserves this function.

The simple methods of comparative anatomy, when used in connection with knowledge of a bird's behavior, in the field or

laboratory, may give clues concerning the function of different parts of the bird's brain. Special adaptations in the general anatomy of birds are so common and striking that it seemed important to compare the brains of many different birds in the hope of finding behavioral correlations. Much careful work has been done on a few species, but a broader survey of the brains of the whole class *Aves* has never been systematically carried out. This general paper describes some preliminary studies and outlines some general problems.

INSTINCTIVE BEHAVIOR

When one compares the behavior of birds and mammals, it is obvious that birds are usually more stereotyped. One is inclined to agree with Mrs. K. Scherman, in *Spring on an Arctic Island:* "we cannot envy the birds for the set and narrow paths of their uncompromisingly efficient lives." Lower forms such as reptiles, amphibians, and fish are even more fixed in their actions than birds, because more of their patterns of behavior are inborn and modified but little by experience. This is not the place to go into a long discussion of "instinct" as a biological concept.

The thesis that all behavior is either inherited (unlearned, instinctive) or acquired (learned)is too simple to meet the facts. It is a question of genetically determined processes being influenced by environmental stimuli. Physical structure and behavior are the result of an interaction of both heredity and environment. Concerning birds, we can say that their behavior is more instinctive than that of most mammals, and much more so than the behavior of man.

Much has been written recently, especially in England, about the behavior of birds. The ethologists have given careful descriptions of the life histories of different single species with emphasis on how much one individual acts like another. They

bring out the importance of inherited patterns of behavior and of rituals characteristic of a species. N. Tinbergen in his *Herring Gull's World* has produced a beautiful example of this kind of detailed observation. He leaves little doubt in the reader's mind that a great part of the behavior of a gull is inherited, stereotyped, and ritualized. Certain acts or series of acts are performed in response to certain stimuli. The mating, nesting, and parental performances are specialized, highly developed, and so uniform for the species that one is convinced that these intricate patterns of behavior are almost entirely instinctive. K. Lorenz (writing in the *Journal of Ornithology*) has made similar studies of ducks and geese and lays stress on the important part played by heredity. A. J. Marshall in his description of the bower-birds [certain birds that build bowers, or runs, used as playhouses and to attract the females, not as nests] of Australia and the neighboring islands gives the most astonishing examples of the building of avenues, bowers, and stages by these crow-like birds. Their constructions are often truly artistic productions. Some of the bowers are so characteristic that they are said to be better taxonomic guides than the skins of the birds themselves.

The riddle of migration and the "homing" ability of birds is far from solved. But experiments on free and caged birds are beginning to give evidence that their remarkable feats of navigation are based on visual cues from the sun and even the stars. Starlings have returned to their nesting places in Germany from as far away as 1,250 miles. E. G. F. Sauer in Freiburg has made a special study of the migration of European warblers and finds that at the times of the year when they feel the urge to migrate, they automatically orient themselves by the stars. Young warblers which have never migrated before apparently can navigate from Sweden southwest across Europe to Gibraltar and thence directly south to Central Africa; and they reverse this course in

the spring. They migrate alone and at night. Sauer calls this "celestial instinct" and asks: "What evolutionary process was it that endowed these animals with the highly sophisticated ability to read the stars?" All this work needs confirmation, but it excites a lively interest even in the mind of the skeptic.

In short, the evidence is overwhelming that a great part of all birds' behavior is instinctive, released by appropriate stimuli in special environments in a quite automatic fashion. Learning seems to play a relatively small part. The opposite opinion, however, is put forward in two recent books by English women, *Clarence, The Life of a Sparrow*, by C. Kipps, and *Birds as Individuals*, by Len Howard, which give evidence as to how individual the behavior of certain passerine [songbirds of perching habits] birds may be. Some titmice and sparrows are remarkably individualistic and learn a surprising amount in a lifetime. The observations are careful, continuous over years, and often backed up by voluminous notes. Julian Huxley says of Len Howard's *Birds as Individuals:* "Miss Howard will not expect professional biologists to accept all her conclusions. But they will be grateful for her facts." The sparrow (*Passer domesticus*) that Miss Kipps raised and kept for twelve years showed an extraordinary ability to adapt to new circumstances, to learn, and to develop a song.

There is great value in these purely observational descriptions of what wild birds can do when tamed and partly domesticated. It is astonishing to see what can be done with patience in the training of house sparrows and canaries when the trainer has plenty of time, as in the case of the *Bird Man of Alcatraz.* Some allowance, of course, must be made for the effects upon observation of the anthropomorphic bias of many amateur naturalists. But scientific experiment often supports these observations. N. Pastore has carried out careful training experiments with canaries and shown that they can learn to make

visual discriminations of a very complex order and can learn to solve problems involving conceptual behavior; in fact, they can handle abstractions. For example, four canaries in the following experiment learned the concept of *uniqueness.* A grain of food was put in a hole in a board among other empty holes, and all holes were covered; the food was covered by an aspirin tablet in one instance, all other holes being covered by inverted screws; in the other instance, the food was covered by an inverted screw and all other holes by aspirin tablets. After brief training the birds would go directly to the unique cover, remove it, and eat the food. Various other experiments and controls led the author to conclude "that either the brain cortex of a bird is capable of more complex performances than has generally been conceded or that the subcortical centres can carry on complex activities usually assigned to the cortex."

SPECIALIZATION

Birds are great specialists. In the twenty-eight orders of the class *Aves,* there is a variation in size from hummingbird to ostrich, and there are extraordinary adaptations to special environments—such as the long, mobile bill of the woodcock, the superlatively keen vision of the hawk, the display plumage of the peacock, and the adaptation of the flightless penguin to an aquatic life. Behavior is likewise specialized, much alike in all members of a species, and often rigid and ritualistic. Of course, among insects, specialization of form and function goes much further. The lower vertebrates—fish, amphibians, and reptiles—also are remarkably specialized in their adaptations. Many mammals too show special adaptations that carry them far into narrow ecological niches. But man is the great generalist.

As Elliot Smith pointed out in *The Evolution of Man,* man reached his height of intellectual achievement just because specialization was somehow avoided in his evolutionary ascent.

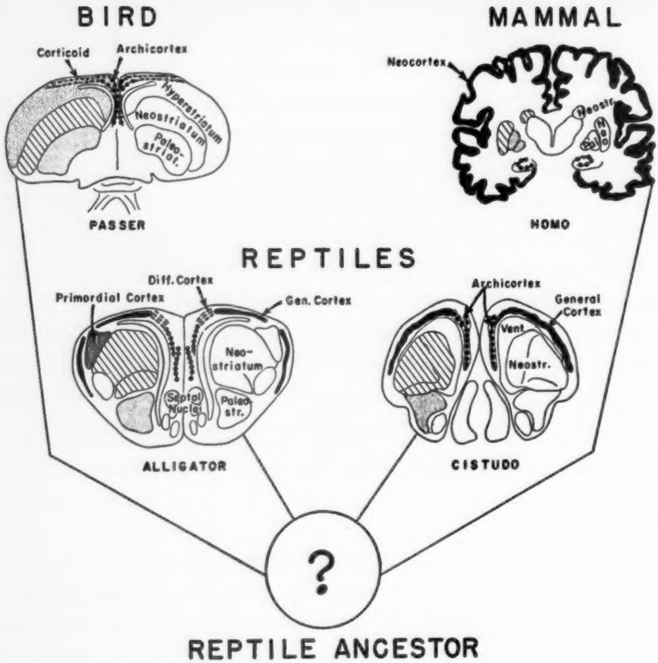


FIG. 1.—*Diagrammatic frontal sections of brains of man* (Homo), *house sparrow* (Passer), *alligator, and turtle* (Cistudo), *showing relationships of corticoid layers in the bird to cortex in the mammal and reptile. Also shown are the relative sizes and arrangements of the different parts of the striatum in all three classes. The hippocampus* (Archicortex) *is indicated in each section as a row of black dots. The anatomy of the brain of the reptile ancestor is unknown, but it probably resembled the brains of the more primitive reptiles living today.*

In the line from reptile to shrewlike mammal to tarsier to monkey and man, the adaptation was more general than special. No predominant sense organ developed at the expense of the others. Tactile sense and manual skill came with the freeing of the hands in arboreal life; skill increased as the opposable thumb

and binocular vision developed; vision was good; hearing, tasting, and smelling were adequate. This well-rounded combination of sense organs produced a brain with evenly distributed sensory receiving stations. The necessity of connecting each of these with all the others favored the development of many short connecting tracts. The cerebral neocortex was the result, present in all mammals and enormous in apes and man. It may have a rudimentary forerunner in the cortex of reptiles (the solid black areas in Fig. 1).

Birds have none of this. The evolution of their brains seems to have proceeded through a great development of the midbrain for vision and of the basal ganglia [nerve tissue] for adaptation. Vision is the dominant sense in the lives of most birds; their mesencephalic [midbrain] optic lobes are relatively enormous. The new development in birds, found in no other class of animals, is the hyperstriatum (Fig. 1). This is a large mass of cells lying in the forebrain hemisphere over the neostriatum, which is also large when compared to the neostriatum of mammals.

In any consideration of the relationship between the avian brain and the mammalian brain, it must be remembered that both are descended phylogenetically from the Mesozoic reptiles. According to T. Edinger in *Evolution*, the typical avian forebrain first appeared in the later Cretaceous period about 100 million years ago, and the avian brain has been developing along unique lines ever since. In no sense can it be considered the forerunner of the mammalian brain. The reptilian ancestors of birds and mammals separated in the beginning of the Mesozoic era more than 200 million years ago; the evolution of the avian brain led to the development of a large striatum plus hyperstriatum; the mammalian line evolved a cerebral cortex or pallium.

POSITION OF BRAIN WITHIN THE SKULL

Before a discussion of the special anatomy of the avian brain, it is instructive to observe the brain *in situ* in the skull and consider its relation to body posture. Primitive reptiles and modern reptiles that crawl on their bellies have a long axis of the body that is carried forward rather directly through skull and snout. As reptiles developed into birdlike forms, this axis radically changed to one that broke in its anterior part to a more or less vertical neck axis sitting on a generally horizontal body axis. The skull, instead of lying in an extension of the body and neck axis, is bent forward in many birds to lie approximately at right angles with the neck, so it sits on the long neck with the *foramen magnum* [an aperture in the skull; see Fig. 3] more ventrally placed. In the pterodactyl described by Edinger, the *foramen magnum* is well around toward the ventral side of the skull, and the spinal cord comes off the base of the brain, being directed almost vertically downward.

In birds it is evident that the skull itself has responded to this change of position by developing a bend between the brain case and bones that support the bill. The brain bends accordingly, so a cerbral axis can be defined and compared to the bill axis. When the two are nearly in line, the skull is called an extended skull; when the brain case and brain are at a considerable angle to the bill, the skull is bent. D. Starck believes that the extended skull in birds indicates a primitive form. Certainly it brings out the superficial similarity between a loon, for example, and a reptile (see Fig. 2). The variations, however, are great from one species of bird to another even within the same order of birds, so these comparisons between brain axis and bill axis indicate special adaptations and are not good taxonomic characters. Variations in the form of skull and brain are common in relation to the development of eye, bill

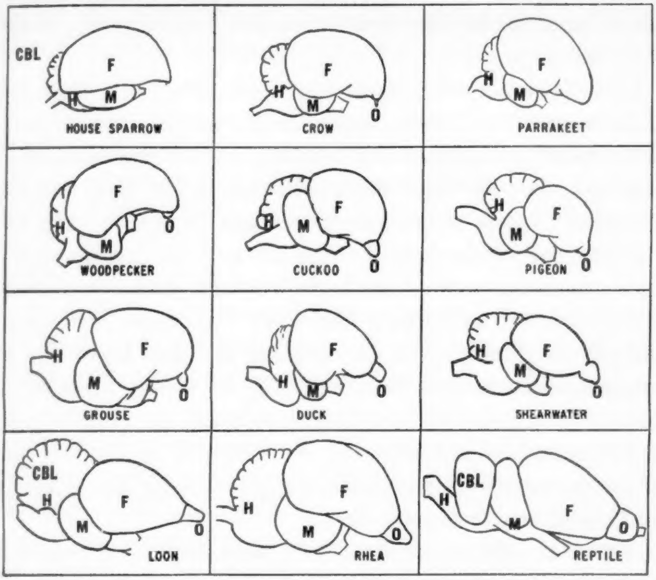


FIG. 2.—*Profile drawings of the brains of eleven different birds and one reptile* (Chelone), *showing relative size of forebrain* (F), *midbrain* (M), *hindbrain* (H), *and olfactory bulb* (O). *The variation in form and amount of bending of the axis is obvious. The cerebellum* (CBL) *is part of the hindbrain and is large in all species, but in those with larger forebrains it is covered to some extent by the posterior* (occipital) *part of the hemisphere. The forebrain is composed of two similar hemispheres, right and left, only one of which is shown in these lateral views.*

and special postures. In describing the pterodactyl, Edinger remarks that "the brain as in birds, formed an arc around the back of the orbit."

This marked variation in the conformation of skull and brain between one order of birds compared to another is best seen when a swimming bird, e.g., a cormorant, is compared with an upright tree bird, e.g., an owl (see Fig. 3). If the cerebral axis is defined as a line from the center of the medulla to the center of the olfactory bulb, its angle with the bill axis may be measured for any species. Such measurements of the brain-bill angle

show the great plasticity of structure in the development of the skull and brain.

One of the most remarkable developments is seen in the brain of the woodcock. This is a night-feeding species, with an enormous eyeball and a long bill for drilling into the mud for worms. The migration of the eyeball backward in the skull was apparently a useful development, perhaps because it gave the probing bird a wider field of vision and kept the eyes out of the mud. The result is that the brain has been pushed backward, downward, and underneath the orbit. The *foramen magnum* actually points somewhat forward, and the brain is indeed "an arc around the back of the orbit" (Fig. 3). But in other members of the same order (the Charadriiformes) the brain is largely above and behind the orbit. For example, the herring gull (*Larus argentatus*) has a brain-bill angle of 34 degrees compared to 117 degrees for the woodcock.

Because evolution can apparently make such marked changes within a closely related group of birds (or within a group of reptiles), one should not think of the extended skull as "primitive" and the bent skull as "recent." Rather must one emphasize the remarkable facility with which evolutionary development, when effected by variation in sense organs and feeding habits, may change the anatomy of the skull and therewith the position of the brain.

GENERAL TOPOGRAPHY

When one compares the gross morphological characteristics of the brain of one order of birds with those of other orders, several differences become obvious. In the first place, the brains of all birds follow a pattern that can best be described in terms of forebrain, midbrain, and hindbrain. The hindbrain is large in all orders, with a well-developed eighth (auditory and vestibular) nerve and a conspicuous trigeminal nerve to the face

and bill. The main differences are seen in the cerebellum, which varies in size from species to species. Since the cerebellum is the part of the hindbrain that controls equilibrium and coordination of motor skills one would expect that birds with swift and skilful flight would have much larger cerebellums than those with monotonously straight flight, but even loons have a good-sized cerebellum, perhaps related to their agility under water (Fig 2).

One of the most characteristic features of the avian brain is the big pair of optic lobes; they are symmetrical parts of the roof (tectum) of the midbrain which have taken a lateral and somewhat ventral position. In all birds they are conspicuous when the brain is viewed from below (Fig. 4). In a side view they are usually partly hidden by the occipital [rear] part of the forebrain hemisphere, their visibility depending upon the relative degree of development of optic lobe and hemisphere in any one species (Fig. 2). The general rule seems to be that birds with the greatest degree of intelligence have large hemispheres that extend backward and partly cover the optic lobes and cerebellum (e.g., crow) while in the less intelligent birds the optic lobes and the cerebellum are more exposed in the lateral view (e.g., loon). The connections of the optic lobes are complex, the largest outflow being upward to centers in the base of the brain, with relays thence to the hemispheres. There are also distinct connections with the hearing, olfactory and visceral centers and the cerebellum. Microscopically, the optic lobe shows large and small ganglion cells arranged in concentric layers. This gives the organ a resemblance to the higher cerebral visual centers of the mammals to which it is not homologous. Its homology is with the superior colliculus, a visual ganglion of the mammalian midbrain.

The avian forebrain has been the subject of much study; modern understanding of its comparative anatomy began with

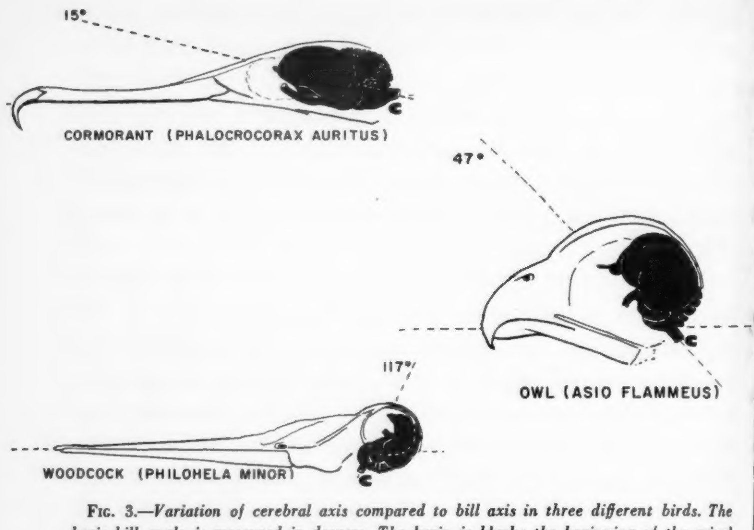


FIG. 3.—*Variation of cerebral axis compared to bill axis in three different birds. The brain-bill angle is measured in degrees. The brain is black; the beginning of the spinal cord* (C) *is shown as it leaves the brain through an aperture in the skull (called* foramen magnum). *The optic nerve* (V) *is shown entering the orbit to reach the eye which has been removed.*

L. Edinger, and has been ably carried on by E. H. Craigie; C. U. Ariëns Kappers, G. C. Huber, and E. C. Crosby, A. Portmann, and W. Stingelin. Anatomical and physiological work before Edinger was mostly confused by the erroneous concept that birds had a cerebral cortex (neopallium) analogous to that found in mammals. The forebrain of birds actually consists almost entirely of thalamus, striatum, olfactory lobes, hippocampus, and some smaller nuclei making up the gray matter; besides this there are the connecting tracts (Fig. 1).

In examining a series of avian brains (Fig. 2), one is struck immediately by the great variation in size of the olfactory bulbs. They lie near the rostral [beak] tips of the hemispheres, sometimes underneath if the brain is bent or if the bulbs are very small. In the loon and shearwater (and other petrels) the bulbs

are large (Fig. 4), rostrally placed, and have conspicuous olfactory nerves running forward into nearby nasal chambers. In pigeons, hens, and hawks they are of moderate size; in passerine birds they are small. For example, they are almost microscopic in the English sparrow (*Passer domesticus*) and fused in the mid-line beneath the rostral tips of the hemispheres (Fig. 4); in the parakeet they are minute but not fused. This variation in anatomy has led to much speculation and some experimental work to find out whether any birds have a "sense of smell" and, if so, in which ones it is well developed.

The striatum makes up most of the hemisphere, and a large and important part of it is the hyperstriatum, a structure found only in birds (Fig. 1). This covers much of the hemisphere surface in passerine birds and parrots; it is somewhat smaller in other birds, but relatively large in all forms. The most superficially placed part of it is called the *hyperstriatum accessorius*, which in many species makes a bulge on the vertex and frontal region (Fig. 5) parallel to the median sulcus [shallow furrow on the surface of the brain separating convolutions], which is the *Wulst* of German authors. Beneath the hyperstriatum lie three large ganglionic masses—the neostriatum, the paleostriatum, and the archistriatum—as well as several smaller ganglions. Near the mid-line along the median sulcus and ventricle is a well-developed hippocampus. It is probably the only structure in the avian brain that should be called cortex (pallium), and it is archicortex. In most species it spreads out to some extent onto the surface of the hemisphere and is then called "corticoid" area. The study of the relationships of these various parts of the forebrain to one another, their relative development, and the relationship of all this to avian behavior is a poorly explored and fascinating field. Two of its several controversial questions will be discussed in some detail: What birds seem to have an olfactory sense? Do birds have a cerebral cortex?

All birds have big eyes and conspicuously developed mesencephalic optic lobes; in some species the optic apparatus is relatively enormous. Hearing is also well implemented by good ears and a large center in the midbrain. Both these midbrain centers have big projections to the forebrain. Field observations show that the lives of birds are largely guided by vision and hearing. Why, then, should one investigate such a relatively unimportant trait as their sense of smell? The immediate motivation comes from the simple, gross comparative anatomy of various birds' brains. There is an obvious marked variation in the size of the olfactory bulbs in different species (Fig. 2). In kiwis and petrels they are big, in sparrows and parrots they are minute. Obviously one cannot discuss the sense of smell "in birds" in general, as has been done in the past; one must compare the anatomy, physiology, and ecology of many different species.

For well over a hundred years there has been a great deal of argument about whether or not birds possessed a sense of smell

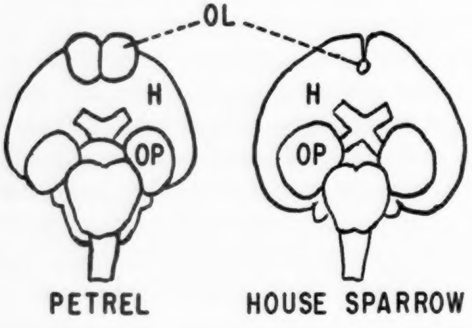


FIG. 4.—*Ventral view of brains of house sparrow* (passer domesticus) *and petrel* (Oceanites oceanicus) *showing relative sizes of olfactory lobe* (*OL*), *hemisphere* (H), *and optic lobe* (OP).

in the way that mammals do—whether they receive particles into their nostrils through the air and register a sensation that is important to them for their adaptation to life. One of the earliest investigators of this question was J. J. Audubon. In 1826 he read a paper at the Natural History Society of Edinburgh in which he gave an account of experiments that he had made concerning the sense of smell in vultures while he was living in the United States. He had heard from many naturalists and hunters who lived in the South, where vultures were common, that they believed the bird found its prey by a remarkable sense of smell which was effective at great distances. He had observed vultures soaring aloft and described how, on spying food below, "the favored bird rounds to and by the impetuousity of its movements gives notice to its nearest companion, who immediately follows him." Audubon believed that vultures watched each other when they were soaring; if one dropped down, the next one would see him fly in and drop in the same place; others observed the second one and so on, until in a short while there would be a whole group of vultures surrounding the desired food on the ground.

Not satisfied with simple field observation, Audubon experimented. First, he stuffed a dried deer skin which "had no smell," put artificial eyes in the head, and laid it out in a field. The vultures dropped from the air after the skin had been left alone a short time. They tried to pick out the artificial eyes, and they tore the skin and pulled out the hay with which it was stuffed. A second experiment was performed by hiding under a pile of brush a putrified hog that to a man had an insufferable smell at thirty yards. No vultures came near. In the third experiment, he raised young vultures and observed that they apparently got their food by sight only. With Bachman, he extended this experiment to a vulture which was blind and would starve in the midst of plenty of flesh in its yard.

Finally, Audubon painted on a canvas a picture of a sheep, skinned and cut open with the viscera pulled out. He put this picture in a field and left it there. In a short while the vultures came down to it and tugged at the painting, pulling it around as if they were trying to eat it. He repeated this experiment over fifty times. In some instances he hid offal nearby, and the vultures paid no attention to it. Audubon therefore concluded, "You will abandon the deeply rooted idea that this bird possesses the faculty of discovering by his sense of smell his prey at an immense distance." Audubon may be right, but his observations give no explanation of the fact that vultures have large olfactory lobes and remarkably large and complex nasal chambers.

Charles Darwin also became interested in this question when he was in South America on his long cruise. He visited a ranch where there was a condor in captivity. This bird was fed meat, which it ravenously consumed. But if meat were put in its yard wrapped in paper, it would pay no attention to it. He agreed with Audubon that vultures had a remarkable visual acuity and obtained their food by that sense and not by smell. Since that time various hunters and naturalists have made field observations on birds. Some hunters believe that wild fowl can smell them, especially if they smoke in the blind. N. Tinbergen has noted that herring gulls did not appear to smell him when he was smoking in a blind, even when as close as one foot to leeward of him. But all these field observations are uncontrolled and not conclusive.

Many anatomists and physiologists have been interested in the fact that in some species of birds the olfactory bulbs are large and in others extremely small. A. Meckel in 1816 published a beautiful figure of a goose brain with a big olfactory bulb. A. Bumm made many anatomical measurements and keen observations. He proposed the generalization that the ol-

factory lobes are large in swimming birds, middle-sized in marsh birds, and small in others. All anatomists agree that they are small in passerine birds. The most authoritative work on the comparative neurology of vertebrates (Ariëns Kappers, Huber, and Crosby, *The Comparative Anatomy of the Vertebrates Including Man*. New York: Macmillan Co., 1936) confirms this in several figures, showing the olfactory bulb in seven species.

The function of these bulbs has been more discussed than experimentally investigated. As mentioned above, the field observations can be disregarded as inadequately controlled. Many training experiments have been carried out with inconclusive results. A few experimenters have tried to establish and record conditioned reflexes. W. E. Walter has done the most careful work and gives a good summary of previous investigations. He concluded that the other experimenters with the conditioned reflex method have been fooled by artifacts. In his own careful experiments on pigeons, he found no evidence that they could be conditioned to smell, although they quickly responded to very slight visual and auditory stimuli. A. D. Calvin, C. M. Williams, and N. J. Westmoreland are the most recent experimenters to employ the conditioning method. They used pigeons, and their results, like Walter's, were negative.

At the present time experiments are being carried out on pigeons in Professor Skinner's laboratory at Harvard by my associate, W. J. Michelsen. The pigeons are being trained in a modified "Skinner box" to peck a certain key when an odor is presented to them and not to peck it in the absence of odor. The exclusion of artifacts has been accomplished quite satisfactorily because the method of "operant conditioning" devised by Skinner gives such an abundance of data that incidental and extraneous stimuli can be cancelled out and the significance of results can be easily computed.

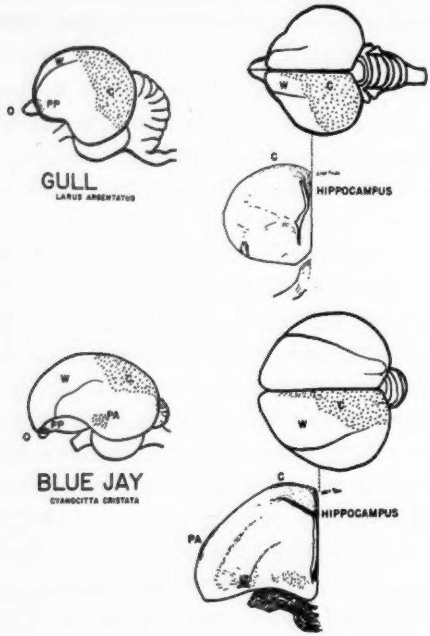


Fig. 5.—*Diagrammatic drawings of the brains of gull and jay showing relative sizes of olfactory bulb* (O), *hippocampus and main corticoid area* (C), *which is continuous with the hippocampus. These structures probably have much to do with smell, taste, and visceral functions and little to do with intelligence. The main mass of the hemisphere is made up of three big ganglia, which together form the striatum* (Fig. 1). *The uppermost of these is called the hyperstriatum and is found only in birds. The top of it forms a swelling on the surface called* Wulst (W). PP *and* PA *are small corticoid areas,* PP *being closely related to the olfactory bulb.*

Two pigeons (*Columba livia*) were trained to make the discrimination between odor and no odor with sec-butyl acetate, a strong smelling substance that is good for teaching the bird, but it is not satisfactory because it might irritate the trigeminal nerve endings. The pigeons were then shifted to iso-octane, a milder odor that affects only olfactory nerve endings. The first

pigeon, in discriminating between odor and no-odor in over 1,000 trials, made 82 per cent correct responses. In control runs with only pure air, correct responses for "no-odor" were given in 54 per cent of the trials. After the controls, in over 2,000 more trials for discriminating between odor and no-odor, the pigeon made correct responses in 88 per cent of the trials. The second bird was similarly trained. The trial runs were the same except that the control runs were made with iso-octane every time. This bird's responses in the control runs were 63 per cent correct. In the discrimination runs before controls, it made 88 per cent correct responses; after the controls, 86 per cent correct. The facts that the number of trials ran into the thousands and that the difference between the figures for experimental discriminations and controls are highly significant leave no doubt that the pigeon can discriminate between the presence or absence of iso-octane in the air of his chamber. The olfactory nerves were then cut in the two pigeons. After recovery from the operation, neither bird could discriminate between the presence and absence of iso-octane, their performance falling to a level lower than that in the control sessions. It therefore appears to be finally proved that the pigeon has a sense of smell.

The common, or rock, pigeon was chosen for this work because it was so convenient and had been so thoroughly studied. From the point of view of comparative anatomy, it is a bird only moderately well equipped with olfactory structures. The greatest diameter of the olfactory bulb in the rock pigeon is 2 mm., of the cerebral hemisphere, 12 mm. This places the pigeon eighteenth in a list of thirty-seven different species of birds arranged from those with the smallest olfactory bulbs relative to hemisphere to those with the largest (see Table 1). A lateral view of the pigeon's brain (Fig. 2) shows the olfactory bulb, the cerebral hemisphere, the optic lobe of the midbrain, the cerebellum, and the medulla oblongata. The olfactory bulb gives

TABLE 1

VARIOUS SPECIES OF BIRDS ARRANGED ACCORDING TO RATIO OF SIZE OF OLFACTORY BULB TO CEREBRAL HEMISPHERE

Species	Diameter of Olfactory Bulb (Mm.)	Diameter of Hemisphere (Mm.)	Ratio of Olfactory Bulb to Hemisphere (Per Cent)	Avian Order
House sparrow, *Passer domesticus**	1.0	13.0	8	Passeriformes
Fox sparrow, *Passerella iliaca**	1.5	13.0	11	Passeriformes
Canary, *Serinus canarias**	1.5	12.5	12	Passeriformes
Crow, *Corvus brachyrhynchos*	1.3	26.0	5	Passeriformes
Jay, *Cyanocitta cristata*	1.0	16.0	6	Passeriformes
Parakeet, *Melopsittacus undulata*	0.8	13.0	6	Psittaciformes
Flicker, *Colaptes auratus*	1.5	18.0	8	Piciformes
Starling, *Sturnus vulgaris*	1.3	14.0	9	Passeriformes
Woodpecker, *Dendrocopos pubescens*	1.5	15.0	10	Piciformes
Cormorant, *Phalacrocorax penicillatus*	3.0	29.0	10	Pelecaniformes
Turkey, *Meleagris domesticus*	2.5	19.0	13	Galliformes
Grouse, *Bonasa umbellus*	2.0	14.0	14	Galliformes
Osprey, *Pandion haliaëtus*	3.0	21.0	14	Falconiformes
Snipe, *Capella gallinago*	2.0	14.0	14	Charadriiformes
Dowitcher, *Limnodromus griseus*	2.0	13.0	15	Charadriiformes
Plover, *Charadrius semipalmatus*	1.5	10.0	15	Charadriiformes
Gull, *Larus argentatus*	3.0	19.0	16	Charadriiformes
Pigeon, *Columba livia*	2.0	12.0	17	Columbiformes
Woodcock, *Philohela minor*	2.5	15.0	17	Charadriiformes
Vulture, *Coragyps atratus*	4.0	24.0	17	Falconiformes
Heron, *Nycticorax nycticorax*	4.0	22.0	18	Ciconiiformes
Owl, *Bubo virginianus*	4.5	25.0	18	Strigiformes
Owl, *Asio flamaneus*	3.5	18.0	19	Strigiformes
Kingfisher, *Megaceryle alcyon*	2.5	13.0	19	Coraciiformes
Swift, *Chaetura pelagica*	1.5	8.0	19	Apodiformes
Duck, *Anas platyrhynchos*	4.0	21.0	19	Anseriformes
Loon, *Gavia immer*	5.0	25.0	20	Gaviiformes
Swan, *Cygnus olor*	6.0	28.0	21	Anseriformes
Cuckoo, *Coccyzus americanus*	1.9	9.0	21	Cuculiformes
Coot, *Fulica americana*	4.0	17.0	24	Gruiformes
Whippoorwill, *Caprimulgus vociferus*	2.5	10.0	25	Caprimulgiformes
Grebe, *Podiceps auritus*	4.0	15.0	27	Podicipediformes
Petrel, *Oceanites oceanicus*	3.5	12.0	29	Procellariiformes
Albatross, *Diomedea nigripes*	8.0	28.0	29	Procellariiformes
Shearwater, *Puffinus opisthomelas*	5.0	17.0	29	Procellariiformes
Shearwater, *Puffinus gravis*	6.0	20.0	30	Procellariiformes
Kiwi, *Apteryx australis*†	..	...	33	Apterygiformes

* These have a single, fused lobe.

† Not measured on formalin-fixed specimen, as were the others.

off a large nerve which extends forward for 4 or 5 mm. as one trunk and then divides into five branches before spreading out into filaments in the walls of the superior nasal chamber. The trunk is easily exposed and cut, which it was in our experiments described above.

Whether or not "birds have a sense of smell" is a question that has to be answered for each family. There is considerable variation within orders—for example, between the sparrow and the starling (Table 1). There is little doubt that the kiwi uses his big olfactory bulb for olfaction. In the tube-nosed swimmers, from the tiny petrels to the great albatrosses, there is a most complex nasal mechanism which employs one set of passages for air and another for liquids. The birds apparently take in air through their nostrils but also use these tubes to eject salt solution and oil. The salt solution comes from the salt gland over the orbit; the oil is regurgitated and enters the nasal chambers by way of an aperture in the roof of the mouth, the choana. Cormorants have moderately well developed olfactory bulbs (Fig. 3 and Table 1) but have no open nostrils. Probably they use the choana as the inlet for their nasal chambers. The nasal cavity of some birds might be an organ for taking in samples of water and "tasting" (perhaps "savoring" is a better word) the suspended or soluble constituents by means of the olfactory nerve endings. Mammals do this by having a very moist nasal mucous membrane on which the particles fall and are then dissolved and "savored" by the olfactory end-organs. Thus a large part of what we call "taste" (i.e., aroma, flavor, etc.) is really smell. Strictly speaking, taste could be defined as the sensation aroused by substances in solution reaching the taste buds on the tongue and buccal mucosa and transmitted via the ninth nerve.

One must not take for granted that a well-developed olfactory apparatus in a bird is related only to feeding. As the Bangs

suggest [B. G. Bang and F. B. Bang, *Bulletin of Johns Hopkins Hospital*], the sense of smell might have to do with breeding. The stomach oil of the tube-nosed birds, regurgitated and then spit out or ejected through the nostrils, seems to be used in sexual rituals, feeding young, and preening. The smell of this oil might be a unique stimulus for recognizing mate and young.

Figure 2 shows profile views of a number of birds' brains. Table 1 gives in millimeters the greatest diameter of the olfactory lobe and the greatest diameter of the cerebral hemisphere for 36 different birds. In column 4 the diameter of the olfactory lobe is expressed as a percentage of the diameter of the hemisphere. The species are arranged according to the relative size of the olfactory bulb: those birds with the relatively smaller bulbs at the top of the list, those with the larger at the bottom. Any one of these measurements is at best an approximation, because they were made from gross specimens fixed in formalin, all of them my own. But even if an error of 2 or 3 per cent is probable in the small brains, the differences are so marked that the figures are significant.

Three birds on the list have single olfactory bulbs—small, fused, mid-line structures: the house sparrow (see Fig. 4), the fox sparrow, and the canary. They are placed at the head of the list as having small amounts of olfactory tissue although their single bulbs may be slightly larger than one of the paired bulbs of other species.

When the different measurements are arranged as in Table 1, the relationships of olfactory lobe to hemisphere vary all the way from 5 to 30. The thirty-six species arranged in this way fall into groups that seem to have a certain order. Five passerine birds head the list and six out of the first nine are passerine. The other three are a parakeet and two woodpeckers. Below this, with percentages of from 10 to 17, is a mixed group of

eleven species, including pigeons, ground fowl, birds of prey, and some water and shore birds. Below this, with percentages from 18 to 30, come sixteen species with the largest olfactory lobes. This group is made up of herons, kingfishers, owls, cuckoos, swifts, goatsuckers, ducks, divers, and petrels. Measurements taken from E. H. Craigie's picture, corroborated by an alcohol specimen of my own, indicate that the kiwi has the relatively largest olfactory lobe of any bird. It could be placed at the foot of the list in Table 1, with a figure of 33 per cent. (The actual measurements from a good formalin specimen are not at present available.)

Measurements of three other ratite [flightless birds, such as ostriches, emus, etc.] birds have been made from Craigie's pictures. These have percentages much alike: cassowary, 20; emu, 21; and rhea, 22. They form a special group because of their ostrich-like build and special skull characteristics. They are considered by some authors to be more primitive than the other birds on the list.

It is interesting and probably valuable to speculate about the meaning of this grouping; the first and last birds on the list are conspicuously different. The kiwi at the bottom is unique with its lack of wings, ground habitat, long bill, and hairy covering. It is said to poke about in the grass and scrub and actually sniff for worms. One wonders whether the large olfactory bulb is the result of usefulness for smelling, and developed by natural selection, or whether it is large because the kiwi is a primitive bird and, therefore, closer to the reptilian ancestors which had large olfactory bulbs. Some living reptiles, such as the turtle (*Chelone imbricata*, see Fig. 2) have olfactory bulbs measuring 36 per cent of the hemisphere diameter.

Near the top of the list are sparrows, the birds with the small, fused olfactory bulbs. They are tree-living forms that eat mainly seeds. It can be reasoned that smell would be little

needed for such a life. As further speculation along these lines, Table 2 was constructed, listing the different orders of birds

TABLE 2

VARIOUS ORDERS OF BIRDS ARRANGED ACCORDING TO RATIO OF SIZE OF OLFACTORY BULB TO HEMISPHERE

Avian Order	Habitat	Ratio of Olfactory Bulb to Hemisphere (Per Cent)
Passeriformes	Trees and shrubs	5–9
Psittaciformes	Trees	6
Piciformes	Trees	8–10
Pelicaniformes	Water	10
Galliformes	Ground	13–14
Falconiformes	Trees	14–17
Charadriiformes	Beach, marsh, and water	14–17
Columbiformes	Trees and ground	17
Ciconiiformes	Marsh	18
Strigiformes	Trees	18–19
Apodiformes	Air	19
Coraciiformes	Water	19
Anseriformes	Marsh and water	19–21
Gaviiformes	Water	20
Cuculiformes	Trees	21
Gruiformes	Plain and marsh	24
Caprimulgiformes	Air	25
Podicipediformes	Water	27
Procellariiformes	Ocean	29–30
Apterygiformes	Ground	33

represented by those measured in Table 1 and their respective habitats in a sequence according to the magnitude of the olfactory bulb-hemisphere ratio. It then becomes obvious that the first three orders are mainly tree-living birds who would have to have odors carried to them through air over some distance. These have percentages of 5 to 10. Next comes a mixed group, with ratios from 10 to 19. Above 19 per cent the marsh and water birds clearly predominate. Except for the kiwi, the largest olfactory apparatus is in the petrel, shearwaters, and albatross (Procellariiformes), which live largely on the open sea. Four species examined had percentages of 29 to 30.

Two exceptions to the wet habitat rule are seen in the list. The Cuculiformes (cuckoos) live in trees. The Caprimulgi-

formes (whippoorwills, etc.) catch insects on the wing. If the ostrich-like ratites were listed, they would also be exceptions, having percentages of 20 to 22. They are large birds, with long legs for running, and live mostly on open, often dry, plains. It may well be that the moderately large olfactory bulbs of these three groups are to be explained more by the fact that these birds are "primitive" than by their needs for the sense of smell. They are all rather stupid birds that do not adapt well to new surroundings; the ratite skeletal anatomy resembles that of the ancestors of birds. In short, they are less highly differentiated in many ways. By contrast, the passerine birds at the head of the list, and the parrots next to them, are among the most intelligent of birds, making complex adaptations to changing environments. There are many observations and a few experiments to prove the marked learning ability of sparrows, crows, starlings, and parrots. L. Kilham's observations on woodpeckers indicate that they are intelligent birds with a high degree of adaptability and mechanical skill. More work is needed on both the anatomy and ecology of all these birds.

In summary, it can be said that in Professor Skinner's laboratory positive proof has at last been obtained that a bird (in this case *Columba livia*) can use its olfactory bulb to discriminate between the presence and absence of an odor in the air of its environment. This observation holds for only one species. The great variation in the size of the olfactory bulb in different orders and species of birds indicates marked variation in function. The smallest lobes (in comparison to the size of the hemisphere) are found in seed-eating, perching birds such as the finches. The largest are found in swimming and pelagic birds. Exceptions to this generalization are the very large olfactory lobes of the apteryx and ratite (ostrich-like) birds, which are generally considered to be primitive and therefore more similar to their reptilian ancestors. It is difficult to make a good theory

as to why water birds have such large olfactory lobes; perhaps marshy environments are more odoriferous and a sense of smell is more useful there. In special cases, like the tube-nosed swimmers and the vultures, the special anatomy of the nasal chambers and the big olfactory bulbs suggest an important function, the nature of which is still obscure.

The question of intelligence in birds has been much discussed and has led to few valid conclusions. Every field naturalist and hunter has his opinions about which birds are "intelligent" and which are "stupid," but these are usually based on unverifiable observations too general to be valuable. Keenness of perception and quickness of reaction are often mistaken for intelligence, whereas they are really quite simple and almost reflex. Intelligence is probably best defined as the ability to react effectively to new and varying circumstances; it may be developed into the ability to form concepts and to use abstractions. Whether or not such abilities are present can be determined only by controlled experiments, such as those performed by Pastore, mentioned in section I of this paper. Field observations can give good clues but are usually too uncontrollable to give important evidence. Pastore, in his closing paragraph, expressed an interest in the neurological basis of intelligence by suggesting that the canary is able to carry out the amazingly complex performances he described either with the "brain cortex" or with the "subcortical centres." My present opinion is that birds have no neocortex and that the "subcortical centres" referred to by Pastore are probably largely in that part of the hyperstriatum known by Germans as the *Wulst*.

Before going farther one must make clear what is meant by cortex. As commonly used the term refers to the layers of nerve cells that lie over the surface of the mammalian cerebral hemisphere (Fig. 1—solid black). In man this is highly developed, and is the organ that subserves a large part of the

more complicated adaptive process, loosely classed as "intelligence." But to merely call it cortex is not accurate enough, because in the deeper parts of the brain are other kinds of cortex, that are older in evolutionary development, and are therefore called *archi*cortex (Fig. 1) as opposed to the more superficial cortex of mammals, the *neo*cortex. The brain centers lying beneath this are deeper and are called *sub*cortical. These and the older types of cortex have more to do with simpler motor, memory, and visceral functions than with learning and "intelligence." It is therefore important to find out whether the corticoid areas in birds (Fig. 1 and Fig. 5, C, PP and PA) are anatomically related to archicortex or neocortex, since that may give a cue as to what part of the brain in birds is the main organ for intelligent behavior. The study of evolution teaches us that both mammals and birds are descended from reptile ancestors, but the line of descent divides and birds go one way and mammals another, so nothing in a bird's brain is a forerunner of any part of a mammal's brain. The two types of brain are different, and which is to be considered more highly developed is a matter of personal opinion and cannot be answered until one answers the second question: More highly developed *for what?* If for vision and hearing and memories related to these, the bird's brain is probably vastly superior. If we are talking about mathematics and philosophy, man must be given the palm.

Starting, then, with an unbiased mind we find that A. Portmann, working in Basel, has shown that the more intelligent birds have larger forebrain hemispheres than their more stupid cousins. This is quite a marked difference, when measured by weight of forebrain as compared to the weight of the rest of the brain. Since the hemisphere of the forebrain (Fig. 1) is almost entirely made up of the big ganglia that together form the striatum, it is reasonable to suppose that it is one of these that

must be especially related to intelligence. In birds the most distinctive ganglion is the one that lies on top, the hyperstriatum (Fig. 1). Several investigators have suggested that it is this organ, especially its most exposed part, the *Wulst* (Fig. 5), that serves to mediate intelligent behavior. This becomes more likely to be the correct interpretation of the anatomy, when one considers that the corticoid layers are small, thin, and more developed in birds that are not especially intelligent and have a sizable olfactory apparatus (Table 1).

Figure 2 shows graphically that the hemispheres of a sparrow, a crow, a parakeet, and a woodpecker are all comparatively large. The remaining species have much smaller hemispheres compared to brainstem. It can be seen that in the top row of three birds the cerebral hemisphere covers up much more of the midbrain and hindbrain than it does in the others placed lower in the figure. This is obvious when one compares the parakeet with the loon. So, from Portmann's index and from photographs, drawings, and measurements (Table 1), one can get evidence that large hemisphere size correlates positively with a high degree of adaptability ("intelligence"). This is, of course, all very general. No sound correlations can be proposed until a great many more experiments have been performed on the adaptations, learning ability, and other indicators of intelligence in birds.

Anatomists seem to agree on one point: that in birds the olfactory lobes and their central connections in the septum and hippocampus are not well developed. But some early investigators (A. Meckel in 1816 and A. Bumm in 1883) noticed the great variation in size of the olfactory lobes and pointed out that they are largest in swimming birds, moderate-sized in marsh birds, and smallest in those birds that live in trees. The main areas of cortex described by Craigie are closely connected with the hippocampus and, in fact, he called them "parahippocampal." Since the hippocampus has olfactory connections, it

seemed worthwhile to compare the extent of the corticoid areas on the surface of the hemisphere with the size of the hippocampus and with the size of the olfactory lobe. The hypothesis was that if these three structures were found to vary together in size, the corticoid areas might be considered as probably related in function to the archicortex and to have little or no relation to the neocortex.

My own observations in a series of fifteen species of birds of eight different orders suggest that when the olfactory lobe is large, the hippocampal and corticoid areas are well developed; but when the olfactory lobes are small, they appear to be poorly developed. Moreover, I find that birds from the orders usually considered more intelligent have smaller olfactory lobes and less extensive corticoid areas than those considered less intelligent and more primitive. There seems to be an inverse relationship between corticoid areas and intelligence.

What is the significance of this anatomical work? It strongly suggests that what the mammal does with his neocortex the bird does with his hyperstriatum. These two organs probably have analogous functions. But from the evolutionary point of view they are not anatomically related; the anatomist would say they are not "homologous." In addition the weakly developed corticoid layers of birds are little related to intelligence, but much to visceral functions. Anatomically they are connected with old structures and have no close relation to the important and extensive neocortex of mammals. It remains for future physiological experiments to prove whether or not we can accept these tentative conclusions drawn from the data of comparative anatomy. It is clear, however, that the bird has a unique type of brain. It is no more to be studied by slavish comparison to the mammalian brain, than the behavior of birds is to be compared to that of man. They are profoundly different.

In America All Women Are LADIES

By FRANCIS LIEBER

The delightful observations of a visiting foreigner in 1835

It is a good and very beneficial trait of the Americans, that they hold women in great esteem. An American is never rude to a woman; let a single woman travel from Philadelphia to Cincinnati, and if she be of respectable appearance, she will not only meet with no molestation on her way, but very soon some gentleman or other will take her under his protection, and she may proceed with perfect safety. The consequence is that many very respectable females, of course not ladies of the higher circles, travel alone in the United States. Nay, if those who have no claim to a respectful treatment move from place to place,

they assume invariably a respectable appearance, without inconveniencing that part of the company, unacquainted with their history.

The Americans are not a race of French agility, and, there-

fore, cannot be expected to show that pliant politeness toward women which depends, in a great degree, upon this peculiar quality; they are not easily excitable, and, consequently, not versatile in conversation; they, therefore, cannot show that quick politeness which depends upon this inventive brightness of the moment; but they are essentially and substantially polite, ready to serve a woman, of whatever class, and to show the greatest regard to the female sex in general.

I have seen a hundred times a woman enter a stage-coach, wait, without saying a word of apology, until a gentleman had removed from a back seat, and then, with equal silence, place herself in the vacated situation. Here I must observe that, in my opinion, an American lady accepts with greater *nonchalance* any act of politeness, than the women of other countries; by which they imprudently deprive their social life of much of its charm. A smile, a friendly glance, a gentle word—who cares for holding the stirrup if he cannot expect this much. Yet, as you may imagine, there are many sweet and lovely exceptions. Women belonging to the industrial classes in America, I have observed to be, in comparison with those of a similar rank in other countries, particularly imperturbable by politeness, perhaps owing to a certain shyness, and, perhaps, it is more observed because you are brought more into contact with people of all classes in this country than in others; for here all the world travels, the richest and the poorest, the blackest and the whitest. (By a report made to the New Jersey legislature, on the 7th of February, 1834, we find that nearly *one hundred and ten thousand passengers* were conveyed between the cities of New York and Philadelphia, by the Camden and Amboy rail-road line, during the year 1833.) How often have I handed a lady into the stage-coach, or picked up a handkerchief, or handed her some dish at dinner, when travelling, without receiving as much as a word in return.

I met lately with a pleasing instance of the regard paid to the female sex in the United States. A separate place has been appropriated to the delivery of letters to females, in New York, and an editor noticing this arrangement and approving of it, suggests the propriety of having an awning or covering of some description to protect the applicants from the sun. Of course, only women who have no servants to send, or no home so fixed that the carrier may take the letters to them, go in *propria persona* to the post-office, and for them was this considerate arrangement made. Had the arrangement in question been made, not for the convenience of females, but in order to separate certain women, always busy about the post-office, from the place of general delivery, the considerate regard for the community would have been equally praiseworthy.

I once saw a young, gay gentleman taking, in a stage-coach, a baby from a lady and holding it in his lap, I should think at least half an hour. I thought it, of course, very amiable, but really I was also barbarian enough to think it quite sufficient, in all conscience, to bear good-humoredly the act of travelling in company of a non-domestic baby.

I have always considered Mahomed very impolite for denying women a soul, but I really wish ladies would keep out of the way where they are not in their sphere. A poor fellow of a traveller wants, for instance, to hear the great men of the nation "talk." He goes to Washington; by eleven o'clock, the morning after his arrival, he proceeds to the senate, though its business only begins by twelve o'clock. He thinks he has secured a seat. But by that time ladies begin to drop in; presently they seize upon all the seats. Very well, allow the poor fellow but a fair *stand*; but no, he is obliged to squeeze himself in a corner, pressed in from all sides; mercy, ye gentle souls, allow him but a free passage from his ear to the debaters, and treat the rest of his body as though it were a bale of cotton under the hydraulic press!

The prayer is said; he stretches his neck like a turtle, and turns his eyes away, in order to bring his ear the better into a position that it may catch a sound, which Echo, more merciful than the ladies, may throw into it. His twisted neck begins to ache; his eyes are closed, he thinks "now for the treat," when, unhappily, some officer of the senate taps him on the shoulder: "Sir, there are ladies coming," at the same time, shuffling and pushing chairs over the heads of innocent listeners and constituents, crammed in like the camomile flowers of the shaking-quakers. At last, the officer succeeds in working a passage, and, lo! as if a canal of bonnets, feathers, and veils, had broken through, in they rush; there is no use in resistance. Without a single "I beg your pardon," or betraying the least sorrow at disturbing you, the ladies drive the poor man out of his last retreat. He must needs give way, the contrary would be rude. The poor man who has come, say five hundred miles, to hear the senate, is standing, by this time near the door, with a longing look toward the president, if he has found an opportunity to turn his head back again; and now the debates begin, but, alas! the ladies, also, begin, and our unlucky traveller retires, all he has heard of the senate having been a lisping from sweet lips, directed, perchance, to a polite senator himself. I truly and sincerely think, that legislative halls are, generally speaking, not places calculated for ladies, for many and, I think, very weighty reasons.

Suppose, the same disappointed man, whom we have seen swimming, without success, against the current in the senate-house, is desirous of hearing an oration on some political subject, to be delivered in a public hall or church. He starts early, to be certain of a place, but oh Jove, protector of the strangers! when he arrives, all seats, below and in the first rank above, are already taken by the ladies, whose pretty heads are in as quick motion as their fans, which gives to the whole scene the appearance of an agitated sea between the breakers. But the

stranger espies a yet empty space; to this he directs his course; it is difficult, and may cost him a flap of his coat, but, never mind, he is anxious to hear the orator of the day. He penetrates, at length, to the spot where he expects to rest in peace. "Sir," says, very politely, a man with a short stick in his hand, "these seats are reserved for the gentlemen who form the procession." Confound it, internally exclaims the disappointed man, and makes his exit. I remember, I was once unable, on occasion of the delivery of a Latin oration at a public commencement of some college, to penetrate a crowd of ladies, composed, almost without exception, not of mothers, but of young fashionables. I am resolved to do my best to get up a *Polite anti-ladies thronging-poor-men-out-of-every-chance-of-seeing-any-thing-Society*.

Every female person in the United States is a lady. But a few days ago, my boy went out with a colored servant, and as they had not returned when it began to grow dark, I felt uneasy, and went to the ferry, on which they had intended to cross the Delaware. I asked the ferryman: "Has a colored woman with a child gone across this afternoon?" describing both. "No colored lady has gone to the other shore," was the answer, not with the intention to correct me, but because the words were more natural to his lips. He repeated, afterwards, "No, sir, no colored lady has gone across, within the last two hours."

I'll tell you more. They had, notwithstanding what had been said, gone across, but in another boat. My boy found a little girl on board the ferry, with whom he soon made acquaintance, and speaking to the gentleman who was in charge of her, said, "I wish I had a sweet little sister like this little girl." "Have you no sister?" asked the gentleman. "No," said my boy, "but I have begged God to give me one." The colored girl, mentioned above, told at home this innocent story, and added, "I did not know where I should look, when the little boy said, he had begged God to give him a sister." *Voilà de la delicatesse!*

These are anecdotes, and must be taken as evidence is taken in court, for what they are worth. I dislike very much picking up anecdotes and generalizing them—the common method of travellers who think themselves very sagacious. It is a poor way of reasoning and observing, and has done infinite mischief in judging of individuals and events, both in history and in our own times, but these are anecdotes of a generic character. I know the state of things, independently of their evidence, and give them because they elucidate the fact; I do not reason from them, but add them by way of illustration.

There are strange inconsistencies in the character of every nation, and one of the strangest in the Americans is the immense freedom young ladies enjoy upon some points and their primness in others. Nothing is more common here than for the young lady of the house, perhaps seventeen years old, to give invitations to a ball in her own name, to single gentlemen as well as others, though there may not be the slightest reason for the mother or father not issuing them in their name. I fancied I had made a great impression upon some unknown beauty when I received my first invitation from Miss So and So. "I invited by Miss X.Y.Z.? She writing my name?" such were my thoughts. It was not long, however, before I discovered my mistake. The mother is put quite in the background. This is village-like, and is rapidly growing out of fashion in the best educated families. As soon as the lady is married, she drops like a Cactus grandiflorus after twenty-four hours blowing; she recedes to give the ground to other young ladies yet unmarried. This is *mauvais ton*, no one denies, and you see less of it in New York than in Philadelphia, in Philadelphia less than in Boston.

An American girl is never embarrassed; a child of ten years, —and I would hardly except a single class of the inhabitants,— receives you with a frankness and good breeding which is astonishing, and I can assure you, not unpleasing. So perfectly

self-possessed are they, that blushing is decidedly of little occurrence. My attention was lately drawn to a young friend of mine, a most amiable girl who blushed; and I then thought how rarely I had seen it. I could remember but a very few girls of a large acquaintance that will now and then be seen blushing, I mean when nothing but false *embarras* is the cause. This pleasing ease and sensible frankness sometimes degenerate, as you may suppose, into unbecoming and ungraceful forwardness.

American ladies are possessed of much natural brightness, and converse very freely, infinitely more so than gentlemen. Altogether, boys and girls are earlier *developed* here than in Europe, partly perhaps owing to the climate, partly because they are allowed more freedom,—left more to themselves. A young man of twenty has a much more advanced position in life here than in England.

Good education among ladies is general. Not a few are truly superior in this respect. I think there must be numbers who are bright and fluent letter-writers, to judge from my own correspondence. I know several ladies whose attainments and natural powers would be a great ornament to society anywhere, whom I count among the most superior minds with whom it has ever been my good fortune to become acquainted.

You wish the ladies described too? I know that we wish as as much to become acquainted with the appearance of the female sex of a country as with their character. But this is no easier task than to give, in a few lines, a description of the scenery of a country; it is, in fact, much more difficult. Yet I will try it; only remember that descriptions of this kind are to be taken as general assertions, admitting of innumerable exceptions. To begin then.—It must be allowed, in the first place, that American women have generally a fine, and—more frequently than women of other countries—a genteel, rarely an

imposing appearance. Their shoulders are generally not wide enough, and too sloping; their busts not sufficiently developed, but the waist is small and round, and the lower parts of the body finely formed; their feet are not particularly good—they are better than German feet indeed, and better than the English. Yet so capricious are exceptions! The smallest pair of correctly shaped feet, so small as would be justly criticized if an artist were to give them to a work of his imagination, and the neatest pair of ankles, with corresponding hands and wrists, that I ever beheld, I saw on this side of the Atlantic.

Their walk is much better than the ungraceful dipping and pitching of the English ladies. Their arms—where are fine arms any longer to be found? Sleeves have spoiled them. Their color —I do not now speak of the arms—is generally delicate, which contributes to give, even to the lowest classes, an air of gentility. Their eyes are not as large as the Spanish, yet they are fine, well-cut, and well set, and of much mental expression. They look bright, and are generally of a fine dark brown color. The general expression of the face is again that of handsomeness and delicacy rather than of great and striking beauty. From all this you will see that American ladies look better in the street than in the ball-room, yet I can assure you you find there also many charming faces. It is a peculiarity of the United States which has often struck me, that there are more pretty girls than in any other large country, but fewer imposing beauties than in Europe.

Before I close my chapter on American beauty—a chapter which, I dare say, has proved very unsatisfactory to you, although I gave you fair warning that it is very difficult for a conscientious writer to generalize such things—I must mention the fact, that American women make most exemplary wives and mothers, and strange, be a girl ever so coquettish—yea, even a positive flirt, who in Europe, would unavoidably make

her future husband unhappy as soon as she were married, here she becomes the domestic and retired wife. That unhappy marriages seem to be comparatively rare in America may be partly owing to the great patience of an American husband, which is again referrible to the greater want of excitability, but it is undoubtedly owing also, and probably in a greater degree, to the temper of the women.

The American women are kind and very charitable; I think they are peculiarly so. Married ladies do not only give, if a case of misfortune happens to present itself, but they undergo considerable personal trouble in compliance with their charitable disposition. And again, I have known here several ladies of the most worldly appearance, living, apparently, but to gain admiration, who, nevertheless, would visit the poor and sick in their humblest dwellings.

A leading anthropologist makes these assertions:

- It is incorrect to speak of "the separate races of mankind"
- The living races of man do not represent stages of evolutionary development

PEOPLE ARE DIFFERENT

Genetically, the human species is "polytypical." The implications of this biological fact are most remarkable—and are even now only becoming more fully understood. Some of them might be listed as follows:

1. Races are not species. It is an error to suppose that racial differences in man correspond in kind, if not in amount, to the differences between animal species: human races are not emergent species in any imaginable sense.

2. The incessant cross-breeding of various groups of mankind —which seems always to have been the case even in early man, and which is increasing very greatly in modern man—would

By Weston La Barre

assimilate any such emergent species, even if they existed. For all races of man are interfertile; and, in the absence of geographic and genetic segregation in man, such species could never become separately established.

3. Besides, there is no adaptive radiation whatever in *Homo sapiens*. Brilliant as the invention of hands has been biologically and adaptively, man has built no bodily specializations of any kind on these hands as such. Functionally, hands vary not at all in racial terms; nor are there in man any adaptations isolated at the ends of divergent non-interbreeding racial radii.

4. In adaptive terms, man seems not to be evolving at all

since he first appeared as man, except in minor perfectings of his vertical posture. But even such mechanical adaptations, like "brachycephalization" or increasing round-headedness, are characteristic of the whole species, not merely of races: these adaptations of one part of his own organism to other parts of it are adaptations coming to be shared by all mankind.

5. Man's material evolution is alloplastic and not autoplastic, anyway. He makes matter outside his body evolve like prosthetic pseudo-organisms, through his own intelligent conscious experiments; these machines make unnecessary any blind adaptive fumblings with his own genetic body. What is evolving is his brain's knowledge of reality, not his body's hit-or-miss adaptations to it. Only in mankind's universal vertical specialization—and in the possession of the hands that make such alloplastic evolution possible—do we find facts of immediate evolutionary magnitude.

6. It is incorrect to speak of "the separate races of mankind." What we construe as "races" are statistical inferences based upon genetic facts. That is, all true racial traits are inherited through the germ plasm but can be seen only in the actual living individual. However, the individual often carries in his germ plasm hereditary traits that are not manifest in his particular body. Thus two brunets can have a blue-eyed child. Likewise, many traits may be inherited and not be statistically significant racially (like having six toes). Or many statistical traits (like stature) may not be wholly hereditary. Furthermore, the number of races we come out with depends entirely on the minuteness of our statistical analysis, and the differing classifications are valid on different levels of abstraction. But, whatever traits we choose and whatever level of analysis we wish to make, the actual statistical distribution of these traits does not for a moment permit any inference of more than relative "separateness."

7. Not only do humans have no adaptive radiation, but their racial traits may not even be adaptive as far as races are concerned. Racial traits probably have more significance for the survival of the species than for the survival of "separate" races.

(Since writing the above for the book in 1954, my views have somewhat shifted focus. Although I do not consider man's major racial differences to be simple adaptations to local environments, there does exist some evidence that the general body size and shape (i.e., proportions) may involve an ecological element. . . .

I have not the slightest doubt that *selection* continues to occur in human beings, but this is by no means the same as *natural* selection at all. For example, there is no reason to suppose that blonds were more numerous than Bushmen ten thousand years ago; in fact, Old Stone Age art found in much of Africa and depicting Bushman racial types suggests that the contrary might have been true. The biological fact that there are now 100,000 blonds for every living Bushman is no sign of superior biological equipment among blonds. In the first place, the population of England in the last four centuries of the Industrial Revolution has increased eight times as fast as the rest of the world *for cultural reasons* (economic-technological), and the area of blondness in North and West Europe some four times the average. For quite accidental geographic reasons, it has been from the area where genes for blondness are commonest that overseas migration has been most easy; and it was in this same area that industrialization and the high population increase had proceeded the furthest and produced the highest population pressure. . . .)

8. The living races of man do not represent stages of evolutionary development or the adaptive progress at large of races.

9. In fact, there are changes in man that have no immediate references to natural selection: for example, all the racial traits

of self-domestication in man that go beyond the universal traits resulting from his human-symbiotic domestication.

10. More than that, these changes incident to domestication are not so much evolutionary as devolutionary (for example, fetalization).

Taken as a whole, these matters make the biology of man utterly unique and altogether fascinating. But even more important, knowledge of human biology gives us a firm basis for ethical and political decision. Likewise, it relieves us of any further concern for certain bogus problems of human organization.

In the first place, human polytypicality means that we cannot speak of a "typical" human being, unless we leave out all racial traits from the discussion: for no individual can be black and white and yellow and red and brown at one and the same time! The "typical" human is hard enough anyway to find statistically. Suppose for a moment we took an over-simplified statistical view of the situation. Assume that we could plot on a bell-shaped curve all the variations in a single trait (say, height) that occur in man. Then if we generously took the middle half of the graph as representing the "typical," we would have one chance in two of finding the typical as thus defined. Then suppose we made 10 graphs of 10 unrelated traits. Our chances of finding a typical individual would then be 2^{10}, or one chance in 1,024. If we took *n* traits (and remember that man has between 20,000 and 42,000 geneloci controlling his genetic traits), then the chances are that this "typical" specimen may never have existed throughout the entire history of *Homo sapiens!*

One can hardly dispose thus cavalierly of a whole species—by suggesting that a typical member of the species probably never existed. Actually, the reasoning above is full of holes. To obtain the above statistical chances, we would have to assume that the trait plotted on each graph was functionally unrelated to

all the traits on every other one of the graphs—an absurd assumption to make of any living organism! (For example, all male white cats with blue eyes are deaf, because these traits are sex-linked in one of the chromosomes.) Actually, of course, some of these graphs could not be made: some differences cannot be plotted as gradations of the same continuum (as linear height can, but as color variation in skin cannot). Men actually vary in *alternative* traits and not merely in continuously varying linear traits. The fact is that man is polytypical in his racial traits, and typical only in his human traits. A typical human being has two hands, two stereoscopic eyes, and two double-arched feet—not two yellow hands, two blue eyes, or two brown-skinned feet!

One error in thinking about race is unfortunately very common; but fortunately it is one on which the scientific evidence is quite unequivocal. This is the notion that the various living races represent evolutionary stages in the development of man—as though the "lower" races were living survivals of earlier human stages of development. Most people have a more or less clear idea nowadays that modern man has evolved from more primitive fossil types, like the shorter, low-browed, stooping Neanderthal "cave man." But they make a wrong inference if they suppose that any living race is somehow "closer" to this cave man; that is, if they assume that one race is physically more "advanced" than the others and that these others in serial order are consequently more "primitive." This can be shown with elegant finality to be nonsense.

Now it does seem that some human traits in some humans are "advanced" in the evolutionary sense, and that others are "primitive" (though we will show later that these designations are wholly misleading when applied to "fetalized" man). But for the moment there does seem to be some justification for saying that the "advanced" traits are those specializations which

are most exclusively human and most divergent from the ancestral norms, while "primitive" traits are those conservative ones shared with primitive fossil types of men—and even with our primate ancestors. Thus the white skins, blue eyes, and vertical faces of some Caucasoids are "advanced" specialized traits, since primates in general are dark-skinned, dark-eyed, and prognathous in facial profile. Similarly, the brown skins, dark eyes, and protuding jaws of most Negroids are conservative or "primitive" traits, since these traits are shared with the primates.

This does not mean, however, we can jump to the conclusion that Negroes are therefore a more primitive phrasing or type of man in the evolutionary sense. Such a conclusion rests on only a narrow selection of the available evidence. If we take other traits, the argument turns somersaults. For example, a long thigh-bone is a genuinely advanced "humanoid" trait, when contrasted with the shorter femur of Neanderthal man and the still shorter femur of the gorilla and the other great apes, our closest living primate relatives. Thus the long thigh-bone of some modern groups like the Patagonians (Mongoloid) and the Scots (Caucasoid) is progressively advanced over the thigh-bone of Neanderthal or the primates in general. Likewise, the more developed human heel is a "humanoid" specialization, which is advanced over the merely incipient heel of the gorilla or the zero heel of other anthropoids and primates. But in both these humanoid traits—long thigh-bone and more pronounced heel—Negroes as a race are the most advanced of all living humans! If we took only these traits and ignored other ones, then we could "prove" that the Negro was the most advanced in the evolutionary sense.

Even more offensive to objective scientific method than the restricted selection of evidence, however, is the falsification of further evidence when it is used. For example, when it has

been rationalized that the Negro is "inferior" on the basis of brown skin, eye color, and prognathous jaw, it is then further supposed that all his other racial traits, like frizzly hair and thick lips, necessarily support this position. But open eyes in the Primate House of any zoo would see that the monkeys and the apes have lank hair and thin lips (for all the prognathism beneath them). Thus the thick lips and frizzly hair of many Negroes—far from indicating any "racial inferiority"—are actually badges of their most pronounced humanoid specialization in these traits. Furthermore, some Negroes are actually a sooty-black in skin color rather than brown, and this is as much a specialization from the general primate brown as is a "white" skin. Therefore, the blacker the Negro's skin, the more humanoid the specialization!

We must face the dreadful facts straightforwardly: relatively profuse body hair clearly places the Caucasoids closest of all living races to the lower primates, while Mongoloids and Negroids are more advanced in their humanoid hairlessness. But, on the other hand, the Negro's broad flat nose and the Mongoloid's low-bridged one are both more "primitive" than the Caucasoid higher-bridged, long, thin nose; while, in this respect, the "Armenoid" nose (mistakenly called the "Jewish nose," since the Jews are not a race but a traditional religious community) would seem the most advanced of all human noses. Once again, a lumbar curve in the "small of the back" and protruding buttocks are distinctly human traits, as contrasted with the ape's forward-bowed back and small buttocks. But in both lumbar curve and buttock protrusion some Negroids surpass all other human races: indeed, among the Hottentots, the "steatopygous" buttocks project from the lumbar region almost horizontally, like a shelf.

But we must not neglect the claims of the Mongoloids to an exaggeratedly human status. Most human front teeth or in-

cisors are half-moon-shaped in cross-section, but a specialized form of incisor sometimes found is new-moon-shaped, concave on the inside surface, or "shovel-shaped" in cross-section. Statistically, the shovel-shaped incisor has a much higher incidence among Mongoloids than among other races. Likewise, in eye contours of specialized human form, the Mongoloids largely monopolize the whole field.

More complete evidence thus destroys the claim of any race to evolutionary "superiority." Thus a Nordic may take evolutionary pride in his specialized blue eyes, white skin, high-bridged nose (but some "Armenoid" Jews surpass him in this!) and curly hair (but here he must take a poor second place to some Negroids!)—only at the expense of soft-pedaling the highly reprehensible hair on his chest and shamefacedly scraping off his matutinal beard as assiduously as possible. Among Mongoloids, even though Eskimos have on the average the largest brains, specialized Mongoloid eye contours, and a high incidence of shovel-shaped incisors—still the prize for being "most human" cannot be awarded to Eskimos, because they do not have the longest thigh-bone, because their hair is straight, and because they are not the most advanced in loss or gain of pigmentation. Negroes might vaunt their thick, everted lips, but not the prognathism behind them; their long legs, but not the brown skin on them; their kinky hair but not, perhaps, the long dolichocephalic skull beneath it; a relatively hairless face, but not the dark eyes in it; a marked lumbar curve and handsomely humanoid buttocks, but not their regrettably lower incidence of shovel-shaped incisors. The truth is that even when only a small set of traits is considered, no single human race has a monopoly on all the "advanced" evolutionary traits. Nor does any race lack some "primitive" traits. White skins persist in being hairy; shovel-shaped incisors may come in a prognathous jaw; and peppercorn hair grows out of a dark skin.

Scientific candor, however, requires mention of the nearest to an exception we know to the above statements, the case of the primitive Tasmanians. This group appears to have a *clustering* of primitive traits, in their dark, hairy skins, dark eyes, prognathism, low receding foreheads, and flat noses. The Tasmanians may therefore represent a genuinely unspecialized phrasing of *Homo sapiens*. But even so, Tasmanians show the "advanced" trait of markedly curly hair; and the case is further weakened in the fact of their extremely short ("advanced") faces. Perhaps the question is somewhat academic, however, since the Tasmanians are extinct as a race. But Tasmanian primitive traits are trivial in scale and in significance, when contrasted with their human bipedality and handedness. The generalization remains that the living races of man can*not* be placed in any linear or evolutionary "ladder" order from "high" to "low" in objective physical terms. (Perhaps this is even true for some fossil human races, for Cro-Magnon man averaged a higher cranial capacity and longer thigh-bones than does the modern European.)

So far as the much touted head form is concerned, racist arguments get into most embarrassing logical difficulties, as they did in World War II. Nordic long-headedness, true, is conveniently shared with Mediterranean Italians—but it is also, most inconveniently, shared in even extremer form with Abyssinian Negroids. Besides, most Germans are not "Nordic" anyway in the trait of long-headedness—actually, the Scandinavians they fought are far more Nordic in this respect (and in blond hair and in blue eyes) than the mixed Germans are. Worse yet is a fact which would distress both Hitler and his critics alike: round-headed humans (Hitler was round-headed) represent a more *progressive* trend in humaniod head form than the admired Nordic long-heads! This would appear to be a sufficient *reductio ad absurdum* of racist special pleading.

Nor can we be sure that "advanced" human traits are advanced in the truly evolutionary sense of being adaptive. Man's modern racial differences are not necessarily adaptive to present environments. It is a superstition as old as the Greeks, for example, that the Negro has kinky hair because it was frizzled by the hot tropical sun and that he has a dark skin because of a kind of cumulative tanning, which in some mysterious Lamarckian fashion became hereditary. It is a modern wrinkle of the theory to suppose that these changes were adaptive. There seem to be several weak spots, however, in this line of reasoning.

In the first place, it is not immediately apparent to the heating engineer just why either a dark skin or kinky hair is adaptive. If insulation from a hot tropical sun is required, then longer and looser hair which trapped many air spaces would be more efficient thermodynamically. (But no, that will not do, because Caucasoids have that, to insulate them from the cold!—and also why do Mongoloids, who live in the same high latitudes and even colder continental climates, have long hair that is merely straight?) Actually, the Negro in Africa has short, tight, kinky hair—which in some of its extreme forms actually leaves the bare skin exposed to the sun's rays between knobby "peppercorns" of hair. Likewise, a dark skin absorbs heat rays more readily than a light skin does—and it is not very clear just why Negroes need skins adapted to keeping them warm in the tropics. Indeed, many such alleged racial "adaptations" may actually be maladaptations. As a matter of fact, we could cling to the belief better if our logic did a flip-flop: a better case could be made for supposing that a dark bare skin (and nearly bare pate) can better radiate body heat than a light-colored hairy skin can. But this at best leaves our Negro "adapted" only so long as he stays in the shade; he is severely maladapted as soon as he steps out into the sun. Also, one is a little puzzled as to why the Negroid Melanesians, in the same hot moist climate as the

Negroid Africans, should by contrast have immense mops of kinky hair, sometimes a yard in diameter, on their black heads.

In the second place, Negro traits may have nothing to do with environmental influences in Africa. The present world distribution of dark-skinned peoples—in a great arc from West Africa at one extreme, through southern India, and into the Melanesian islands of the Southwest Pacific on the other—constitutes some of the evidence for a hypothesis that Negro peoples came into Africa from other latitudes, in fact from another continent. Also, even the most far-flung dark-skinned peoples (from the Congo to the Pacific islands) are all predominantly agriculturalists. This fact suggests that they had contacts with the southwest Asiatic cradle of agriculture and may have entered their present habitats only eight to ten thousand years ago—when their complex of racial traits must already long since have been formed. And if environment is king so far as skin color is concerned, some sharp-eyed reader is going to raise the question as to why the lighter-skinned gorilla race lives in the same West African lowlands as the darker-skinned Negroes—while the darker-skinned form lives among the lighter-skinned Negroes of the East African highlands. The environmentalist would have to beg off as best he could by saying that separate primate species are involved (though the environments are the same) and, besides, the East Africans are not a pure race—so please don't bring up any more questions like that.

Then what about the "separate" races of man? Here the anthropologist is back on the safe ground of professional consensus: it is a mistake to suppose that human races are genetically quite "separate." We have already noted earlier that, physically, all the races of man have many times more human traits in common than they have racial traits, even with relative separateness. A very simple mathematical calculation shows the fact of human genetic relatedness in another way. Assuming

one male and one female parent for each individual in the series, the number of ancestors a living individual has only fifty generations back—which takes us only to the Middle Ages—is, theoretically , 2^{50}. That is, for fifty generations (of twenty years each) for the last thousand years, the number of grandparents would double with each generation: two parents, four grandparents, eight grand-grandparents, and so on. Now, numerically, 2^{50} is 1,125,899,906,842,624. But we know quite surely that there were never 1,125,899,906,842,624 individuals alive to be our individual's ancestors during any one generation of the Middle Ages: the total population of the entire world in the Middle Ages was considerably under half a billion, a figure reached only in the mid-seventeenth century. But, furthermore, 1,125,899,906,842,624 is a figure immeasurably greater than the total number of all the human beings who have ever lived in the entire world since *Pithecanthropus erectus*. Yet, even so, to go back to the Stone Age of, say, half a million years ago, we need, conservatively, $2^{25,000}$ ancestors mathematically, not a paltry 2^{50}, which is far too picayune a fiigure. These calculations, of course, refer merely to the ancestry of a single living individual and must be multiplied by a figure which is the sum of all the other living human beings whom we regard as "unrelated" to this individual and to one another—a product which in a race-proud individual might exceed the total number of atoms in the solar system.

The fact is that the more race-proud a man's ancestors were, i.e., the more inbred, the fewer the actual ancestors this individual has had. Indeed, where we can actually trace it historically in European royalty, there is a startling numerical "loss of ancestors" and a corresponding increase in individuals who must double up as ancestors in several lines or in several ways. There is little doubt that the Cockney may easily have more individual ancestors than the king. Also, the lowly, despised

Anglo-Indian has certainly more than the Cockney. Meanwhile, Charlemagne was probably an ancestor of all three—though the Anglo-Indian might also claim descent from the Emperor Asoka, Chandragupta, and Jenghiz Khan to boot. Likewise, Alfred the Great (ancestor of European royalty and of Charlemagne) is probably related to Sun Yat-sen via at least one line (possibly the late Joseph Stalin's), if you take common Stone Age ancestors into account.

Obviously, our actual genetic ancestors were fewer in number than the theoretically possible ones; even if all of them are ancestral to us in one line or another, the total number of human beings in 500,000 B.C. is far too few unless most of them are ancestral to us in thousands of multiple ways. Only past inter-breeding and complex duplications of ancestry and the blameless innocent marriage of unbeknownst fifth (or a hundred and twenty-fifth) cousins can account for this stupendous "loss of ancestors." Plainly, the farther back one goes, the more likely he is to find an individual ancestral to him in two or more lines. And, similarly, the farther back we go, the more likely we are to find a common ancestor of two or more living individuals in the same social group. (The writer, an "Old American" of barely over three hundred years' standing, used to go duck shooting with a friend in one of the old pre-Revolutionary villages of the United States. It occurred to us once that we were probably related. Some genealogical research established that we were indeed seventh cousins twice removed—his rural ancestors had married earlier than the writer's urban ones and had slipped in a couple of extra generations since the eighteenth century—all of which was a gratifying discovery, but got us no ducks.)

No doubt many of the so-called "poor whites" in the Appalachian backwoods are each descended from Charlemagne in a dozen different ways apiece, but never found the time, the money, or the energy to look it up. This crossing and re-crossing

of lines is the same fact that is attested to in the common sharing of the bulk of their genes among all present-day races and among all individuals within a "race" (however defined) to an even greater degree. Biologically, all men are at least distant cousins, if they are not literal brothers in one generation. With this slight rephrasing, the moral perception of the ancient Aramaic traders and teachers and travelers is sound physical anthropology.

In a polytypical species like man's, whose types interbreed, it is much oversimplified to think of a mere "branching" of human races from one single hominid bole. A many-trunked banyan tree, which sends new trunk-roots down to the ground from its branches, is a better basis for conceptualizing the facts. But even this is a poor figure for analogy. In mankind's family tree there has been as much convergence of roots and branches as there has been divergence. If the part above the ground is what we know historically as *Homo sapiens* and the part below the ground as paleontological hominids, then we would have to imagine the paleontological "roots" of the tree as having anastomosed (or grafted onto each other organically)—quite as have the branches, to our knowledge, in anthropological history. This strange reticulated or net-like organism might then somewhat resemble mankind as it is genetically. (In this, human races are like dog breeds. It is a known fact that the "Doberman pinscher" was put together by a dog breeder of this name, out of pinscher, mastiff, shepherd, and hunter strains. Subsequent in-breeding and selection stabilized the new "breed" traits; and now this hodgepodge of canines wins prizes at dog shows on the basis of masquerading as a "pure race"!)

For polytypicality and interbreeding do make mankind at large just such a netlike unitary genetic organism. Von Uexkull puts the matter picturesquely:

The difficulty of picturing the species as consisting of numerous individual organisms and yet being an entire organism itself, depends only on the fact that the separate creatures do not perform their actions at the same rate or at the same place. Let us imagine the species as, for instance, a large shoal of fishes hunting a great quantity of pteropods, and followed in turn by a number of sharks. We at once get the impression of a huge organism, pursuing and pursued, which now spreads out, but fundamentally remains the same throughout. At one point speed, at another slowness, at one point coloration, at another light, here sharp sight, and there a keen sense of smell, act for the preservation of the whole. So long as the whole retains all these properties, it will continue its existence unchanged, although that essentially consists of perpetual flight and pursuit.

This concept applies with special force to *Homo sapiens*. Mankind is at least three such great shoals of individuals—white, black, and yellow, with many admixtures of each. So conceived, the human species can easily be seen as an enormous independent organism, with a character of its own and with tremendous longevity. We shall later present linguistic and cultural evidence to show that, in humanly significant terms, groups of men *can only be understood* in their functional relatedness to one another and as members of one another. But for the moment we wish to deal only with the literal fact of the matter in genetic and biological terms.

Polytypicality in humans is a biological phenomenon with very great survival value. Its potentialities are certainly as great as those arising from the exchange of nuclear material by two paramecia; its promise for the future is surely as magnificent as was the first joining of two heredities in the sexual fusion of two single cells. Indeed, human polytypicality is an extension of the same process, though on a far grander scale; and the increasing scope of human exogamy (or out-breeding) is not merely our historic fate but undoubtedly also our evolu-

tionary salvation. Suppose that some nearly world-wide catastrophe occurred, say a great atomic cataclysm. If some individuals on its margins were to survive on the basis of skin color (that is, some colors would reflect or absorb the rays selectively more or less than others), then mankind could still regenerate itself, and in all its former varieties. For with genetic mixture, the color of the individual's skin is not necessarily equivalent to the skin colors his genes are able to reproduce; the more racial out-breeding there is, the more this is the case. Plainly, the theoretical limit of human exogamy is biologically the most promising, and we neither can nor ought to do anything about it. In our hypothetical atomic conflagration, the genetic richness of *Homo sapiens* would therefore give continued viability to the species, for all that one apparent race (like the Doberman pinscher among dogs) had temporarily ceased to exist. For this reason, again, we cannot say that racial variations necessarily have any adaptive survival value as such to the race —though mankind at large enjoys the survival advantage inherent in all possible racial variations. For—who knows?—at some still farther future, perhaps the other human skin colors may have some survival value for the species.

However we look at the matter, the fact seems to be that *man's racial differences are quite without any immediate small-scale evolutionary significance whatever.* Another reason for this is that man is no longer subject as an individual to the full effects of natural selection and to the other evolutionary mechanisms which operate on wild animals. As soon as the first hunter in the first human society shared his kill with older men and with women and children or fought off some human or wild enemy, these dependents ceased to be wild animals relying for survival on their own efforts and were removed as individuals from the operation of natural selection. In human groups the conditions for survival—whether of mystics, Bab-

bitts, schizophrenics, or idiots—are largely set by the unwitting cultural "choices" or learned preferences of the society itself. Thus man as a culture-bearer is largely the arbiter for the survival of individual human animals—and not nature. Therefore, if nature does not set the conditions for selection, it is difficult to see how "natural selection" could operate on individual man.

This reasoning is supported by a number of other facts. For in the technical sense, man's biological nature is precisely that of a domesticated animal, that is, of a self-domesticated animal. This fact was noted as long ago as the end of the eighteenth century by the great anthropologist Johann Friedrich Blumenbach. Hahn defined a domesticated animal as one in which man had for generations intentionally influenced nutrition and reproduction. The variations which occurred (hair form, pigmentation, and the like), Fischer and others have regarded as biologically neutral, neither adaptive nor anti-adaptive. So far as humans are concerned, anthropologists would agree that, once again, no "genealogical ladder" of mankind is possible in these terms, because the diverse traits of domestication are biologically random.

Man fits all the criteria now used to define a domesticated animal. These are: a *controlled food supply*, which man's cultures secure for him; *human selection of traits*, for man's cultural selections control the traits of "breeds" of men just as the animal breeder's choices and preferences shape the appearance and the heredity of a breed of dogs; and *protection from natural enemies*, which man's social habits and cultural inventions achieve for him. (But if man-in-society constitutes the "natural" enemy of man-in-another-society—a point to be discussed elsewhere—it may be that selection continues to operate, not in terms of individuals, but in terms of societies.)

The many traits which man breeds into his domesticated animals, but which are uncommon or lacking in wild forms, are very easily observed. For example, while both blondness and pure blackness are rare among wild animals (the rare black panther and the black bear are exceptions), nevertheless in all his own domesticated animals—whether horses, cows, pigs, cats, dogs, or chickens—man has created both blond and black forms. White breeds of domesticated animals, as it happens, would be severely disadvantaged in the wild state, quite apart from their higher visibility to natural enemies, and would probably not survive out of domestication so far as those depending on a sense of smell are concerned. In all animal groups, individuals that lack pigment are poorer in sense of smell than are the darker individuals. (For instance, white hogs in Virginia commonly die because they cannot discern through smell the difference between the poisonous *Lachnanthes* root and other roots they feed on, though pigs ordinarily have such a good sense of smell that in France they are used instead of dogs to sniff out underground truffles. Parallel cases are the white rhinoceros in Africa and white sheep in southern Italy, which sometimes eat poisonous grasses.) The reason for this deficiency is that in animals with a highly developed sense of smell, both the olfactory mucous membrane and the entrances to the olfactory organ are normally deeply pigmented. Thus when pigment is bred out, the domesticated animal's sense of smell is also injured, probably to an extent endangering its survival in the wild state.

The similar traits for which man must be adjudged a domesticated animal have now been plentifully demonstrated by physical anthropologists. For one conspicuous example, the "natural" color of man both as a primate and as a mammal ought to be brown—but *Homo sapiens* has such extreme "domesticated" forms as the blond Scandinavian and the black

Gold Coast Negro. So far as pigmentation goes, the microscopic structure of the Nordic eye is identical with that of a blue-eyed rabbit; and human blondness of hair is of the same order as blond hair in domesticated pigs and horses. Variable hair form, present in man, is also notable in dogs, from the Mexican "hairless" to the shaggy Scotch terrier. Long head hair in some humans is paralleled by that of Angora cats, goats, alpacas, and the like. The curly hair of some poodles and the curly feathers of some fancy breeds of fowl are strictly comparable to the frizzly hair of the Negro as traits of domestication. It is a wry commentary that Barnum's "wild man from Borneo" should in his frizzly hair actually have the most domesticated form there is (short of the Hottentot's peppercorn hair), since the hair of most wild animals is straight. There are, of course, no "wild" human beings living in a "natural" state; all human groups live strictly within the technical conditions of domestication.

The great variation in size of domesticated animals (the Shetland pony and the Percheron or Clydesdale horse, the Chihuahua and the great Irish wolfhound, the Bantam and the Rhode Island Red) are paralleled in humans by the Pygmy versus the tall Scot, by the Negritos of Malaya versus the tall Patagonian Indians, and by the shortish Hopi versus the more than tallish Nilotics such as the Watusi. Indeed, recent fossil finds (*Meganthropus*, *Gigantopithecus* versus *Pekinensis* and *Pithecanthropus*) strongly suggest that the same variability in size among modern African Negroids already existed in the protohominids of Asia at least. This tendency toward variability even seems to be a trait of all the anthropoids, where conditions of breeding and group living may tend to parallel the human state: we have mentioned the two "races" of gorilla, but primatologists also count two orangutan races, three chimpanzee, and five gibbon races (if siamang is included). In

man, one function (among others) of living together in societies is so obviously the protection of variability that terrorist "right-thinking," both communist and mccarthyite, is quite plainly anti-eugenic. A democratic live-and-let-live policy, therefore, is basically necessary for the best operation of human biology.

The "domesticated" matter of diet in man deserves further emphasis, for nutrition is everywhere fundamental in biology. In the long view of paleontology, nothing so clearly announces the fading of a promising phyletic future as a narrowed and finicking diet. It is all the more ominous when there is actual anatomical specialization exclusively for ant-eating, blood-sucking, or the like, and not merely a physiological specialization, like the panda's preference for the leaves of a certain species of bamboo or the silkworm's preference for mulberry leaves. Too fine an adjustment to one small facet of the environment leaves the animal all too vulnerable to a minor environmental change in just that feature. If that bamboo bough break, so to speak, the whole panda family is in for a phyletic fall.

On the score of diet, *Homo sapiens* is among the safest of all animals, because he is omnivorous. His heredity is a mixture of happy accidents. His mammalian ancestors ate insects. His primate ancestors learned to eat fruits and plants as well. And by Pleistocene times (if not earlier) the early humans were also carnivorous, as witnessed by the abundant Old Stone Age spear and arrow points used for killing animals. Man's omnivorousness gives him unusual ecological elbow-room; for since he can subsist on a variety of diets, he can invade almost any environment. (The omnivorous potential of the bear family is the major reason why bears, like man, have invaded a variety of environments from the boreal to the tropical, and from the Himalaya highlands to the semi-marine habitat of

the polar bear. But some of these bears specialize; only those that continue to be omnivorous have the same safety as *Homo sapiens.*) Man's tooth structure clearly indicates—from biting incisors and tearing canines to grinding molars and premolars—the omnivorous potentialities of man. Whatever racial variations occur (like the shovel-shaped incisor of Mongoloids) have no meaning as an "adaptation" to a given food.

The significant thing is that everywhere man's ecological adjustment to specific food staples is an entirely cultural phenomenon, dependent upon traditional habits only and hence modifiable, and is never anatomical or genetic. Any change of environment by migration, any climatic change in the environment itself (e.g., man's neo-primate carnivorousness in the Pleistocene), and any change in cultural habits, all leave man free to adopt new diets. On the one hand, man everywhere remains basically omnivorous, since even the meat-eating Eskimo eat some plant foods, and since even the rice-eaters of the Orient eat some meat and fish. No race, that is, exists within nutritional conditions which would either facilitate or require anatomical specialization. But above and beyond this, the slow but steady mixing of the genes in slow-breeding man is still sufficient in itself to counteract any radial specialization, even if this incipiently existed. Meanwhile, there is nothing in a mouth with a shovel-shaped incisor, for all the rice-eating habits of its owner, which prevents it from eating sweet-and-sour pork, a well-cured sea slug, cuttlefish-walnut, bamboo shoots, or a twenty-five-year-old egg.

BY CYRIL STANLEY SMITH

Metallurgy, which today is fast becoming a science, is paralleled only by agriculture and ceramics in the earliness at which real knowledge appears in man's history. Subtle aspects of the behavior of metals, discovered and used five thousand years ago, are only now yielding to theory and becoming part of the science of matter.

Science and Art

in the History of Metallurgy

In the development of most fields of science there is a period when the essential phenomena are first noticed and put to practical use before any scientific theory is developed or the nature of the phenomena is really understood or explained.

This period may be a short one. Sometimes, as in the case of nuclear disintegration, the theory comes soon after the first observations are made; and then new knowledge increases rapidly and grows largely inside the

theoretical framework. Nuclear disintegration, of course, is a phenomenon that could not even be observed until men had acquired a great deal of complex theoretical knowledge and scientific technique, and its practical use required even greater technical knowledge.

But, if the phenomena are easy to observe and use and it is only the reasons for them that are complex, the empirical period may last for centuries or longer. Practical men will find out a great deal before theoretical science even enters the scene. And, when at last it does come, it will do less to explore unknown territory than to explain and enrich what is already known.

There is perhaps no field in which this is more true than in metallurgy. [Metallurgy is the science and art of extracting metals from their ores, refining them, and preparing them for use.] It is one of the oldest of the practical arts—only agriculture and ceramics are comparable in their antiquity. Yet, subtle aspects of the behavior of metals, discovered and used five thousand years ago, are only now yielding to theoretical study and becoming part of the science of matter.

The goldsmith of 3,000 B.C., using a low-melting alloy with the right interfacial energy, and the ax-maker hardening and alloying copper chemically reduced from its ore, were intelligently using many properties of matter that the physicist has just begun to comprehend in the twentieth century.

Today in the field of metals science can point the way to great improvements and speed enormously the finding of a proper solution to any preconceived problem. But, even now, most of the properties used by the artisans of old or by modern industry are still unpredictable in detail, and they may forever remain so because of their inherent complexity.

Both the newness of scientific knowledge in metallurgy and some of the complexity of the problems it deals with can be

illustrated in the story of one persistently popular concept—that vibration causes metals to crystallize. The idea is rubbish, but it was seriously debated by some experts for more than half a century. Even today, the average layman who knows a little about metals still believes that it is true.

It seems to have arisen early in the nineteenth century, when the breaking of iron axles on the first railroads caused a series of terrible train wrecks. This drew attention to an old observation—that wrought iron fractured by repeated applications of relatively low loads had a faceted appearance, while the same material broken after one or two strong bends had a woodlike, fibrous fracture. No one who looked at the fibrous fracture of the ashen whiffletree of the one-horse shay would have suggested that its century of service had made woody cells grow in it—they could be seen all the time. But in metals the internal structure was not so easily seen.

We know now that the faceted fracture was caused by cracks cutting through the thousands of tiny crystals already present in the iron without causing much over-all distortion of them and that, when the iron was broken at higher stresses, the same crystals extended considerably, became drawn out, and revealed a silky texture that was made truly fibrous and like splintered wood by the presence of multitudinous stringers of slag impurity in the rolled-out rods of wrought iron. But it was hard for men to realize that a material could be simultaneously crystalline and ductile, and metals are just that.

Whatever its external shape, any piece of metal is composed of myriads of tiny crystals. Their close and generally random packing together prevents the crystals from taking the beautiful regular polyhedral shapes so much admired in selected natural samples of minerals, which are always brittle. They are, nevertheless, good crystals in their internal structure, and the properties of metals could not be understood until this fact

was realized. It was realized only recently, but clues to the truth had been seen and studied for centuries.

The medieval alchemists had a hint in their Star of Antimony, an easily visible crystallization pattern on the surface of a pure metal casting. The alchemists, however, were interested chiefly in interpreting color changes in Aristotelian terms, and, since Aristotle held that metals were essentially structureless and homogeneous, they were not disposed to search for internal structure. They saw the Star of Antimony only as a mystic sign, not as a key to the manner in which the unit parts were arranged.

The appearance of fractured metal was a far older and more fruitful clue. Even the first workers in bronze must have noticed that too much tin (or, more likely, tin ore, since they apparently did not use the separately smelted metal at first) not only made the bronze brittle but gave a whiter, faceted fracture in place of the fibrous texture normally shown when the tough reddish metal was broken.

In sixteenth- and seventeenth-century writings the fracture test is clearly described as a method of testing the quality of bronze, iron, and steel. In the eighteenth century it was used by the great French scientist Réaumur as a tool for studying the effects of variations in steel-making methods and in following the progress of cementation when steel was made from iron. From his observation of the clumps of particles he could just see in the fracture of his iron or steel bars (Fig. 1), Réaumur developed what was in its essential features a correct theory of steel. He postulated that there were several stages of structure smaller than the one he could see (Fig. 2) and that particles of a different substance worked their way between the particles of iron when it was converted to steel. He also suggested that when the metal was hardened by heat treatment these foreign particles became incorporated in the clumps of

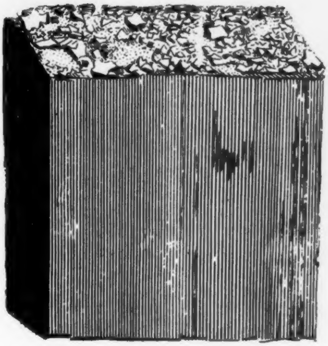


FIG. 1.—*The appearance of the fracture of a slightly brittle wrought iron bar.*

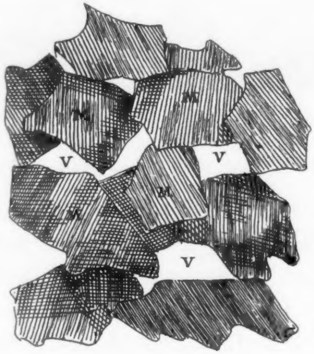


FIG. 2.—*Réaumur's drawing of the hypothetical structure of "a grain of steel as it would look if it were greatly enlarged."*

iron particles or were rejected from them into intervening space.

Réaumur was inspired by Cartesian ideas of the corpuscular nature of matter, and he was right, but he was far ahead of his time. It was many years before men were able to identify his foreign particles as carbon, and longer still before they saw that the reason for the clumping was the geometric force of crystallization.

It was less than a century ago that the structure of metal was finally seen in a way that could be easily interpreted. It was seen then under a microscope, with the aid of a technique

FIG. 3.—*Point of sword blade, Lorraine, sixth century, repolished and etched. Enlarged*

of ancient artisans—the chemical etching of a well-polished metal surface.

Scientists know now that light etching, properly done on a carefully polished surface, will reveal the details of crystallization because of differences in the rate of attack owing to local variations in either composition or orientation. But the process was already known and used for practical and decorative purposes more than a thousand years ago.

THE FIRST ETCHINGS?

Differential chemical attack on metals was used at least as early as the second century A.D. on the pattern-welded swords of the Viking warriors. The Vikings made them famous, but they probably originated in the Rhineland and were widely used by the Merovingian Franks. The point of one of these swords, freed from rust and re-etched, is shown in Figure 3.

FIG. 4.—*Detail of an etched hunting sword, Munich, 1540. (Wallace Collection, London.)*

The pattern results from the use of strips of iron and of steel, welded together, twisted, and forged out to make the center of the sword. The zones of steel appear darker after etching than do the neighboring areas of nearly pure iron. The pattern became a kind of trademark of a good sword because it guaranteed that the metal had been extensively forged, although a less decorative pattern might have been mechanically better.

In Europe the manufacture of these swords ceased after the tenth century, when they were displaced by more homogeneous blades, supposedly better heat-treated. Etching did not reappear until the fifteenth century, when it was used to produce decorative designs on armor. The armor was etched by coating the steel with a protective wax or varnish, gently scraping it away in lines or areas to form the design, and then applying a corrosive medium, usually a mixture of vinegar with substances like salt, vitriol, alum, and sal ammoniac. The solution dissolved the unprotected metal to an appreciable depth and left it rough and dark, while the rest of the surface remained bright. The effect did not depend in any way on the structure of the metal, and it generally masked the structure rather than revealing it.

There is at least one object of this period, however, in which the nature of the metal enriches the design—the hunting sword made by Ambrosius Gemlich of Munich in 1540 (Fig. 4), where the details of the sky come from laminae in the steel. This seems to have been a lucky accident. The effect was not intentionally used in other art metalwork of the time, and in European science it was not until 1762 that a French metallurgist named Grignon made the first observation that etching could render inhomogeneities in metal visible.

THE SWORD OF DAMASCUS

Long before then, etching had important applications in the East. The famed sword of Islam, the Damascus blade, owed its superiority to the fact that it was made of a high-carbon steel which possessed a clear structure of iron carbide interspersed among iron-rich crystals. The finished blades were always etched, and, when the sword had been made well, etching brought out beautiful markings in the steel. An example is shown in Figure 5. One Islamic poet of the sixth century described the effect as "wavy streaks . . . glistening . . . like a pond over whose surface the wind is gliding."

The etching of the swords of Islam had more than a poetic value, however. If the composition of the steel was wrong, or the blade was maltreated in forging or heat treatment, etching would reveal the disappearance of the texture or a marked change in it. The Oriental smith could, therefore, always check his work by observing the "water" on the finished blade, while to the purchaser the marking was a guarantee of quality. This gave a degree of process control that was non-existent in Europe, where structureless surfaces were burnished to insignificant glitter and a good blade was far more subject to chance.

The supreme metallurgical art, however, is evidenced by the Japanese sword. This blade, like that of Damascus, had a visi-

FIG. 5.—*Detail of Persian sword, showing damask with cross-markings known as Mohammed's Ladder.* (*British Museum. Courtesy of Herbert Maryon*). *Enlarged 3/2.*

ble surface pattern which was valued for its aesthetic qualities but which was of metallurgical origin and was definitely related to the desirable internal structure of the steel. This structure resulted from elaborate forging and heat-treatment procedures that were well developed by 750 A.D. and reached their height in the thirteenth and fourteenth centuries. The steel of these swords was far superior to any other steel not made under modern metallurgical control, and the weapons owe both their beauty and their gruesome serviceability to a kind of metallographic quality control.

The blades are not uniformly hard but have a soft back and an intensely hard cutting edge. The hard edge, or *yakiba*, was the most important feature in judging the quality of the blade. Thousands of variants were made, according to the preferences of individual smiths, but the sixteenth-century sword shown in Figure 6 is representative. (The structure of this sword was brought out by etching in the author's laboratory to make it easier to photograph than the beautiful but very subtle original Japanese polish.)

The massive white areas at the cutting edge of this blade are of hardest steel. They pass into the darker, softer steel of the

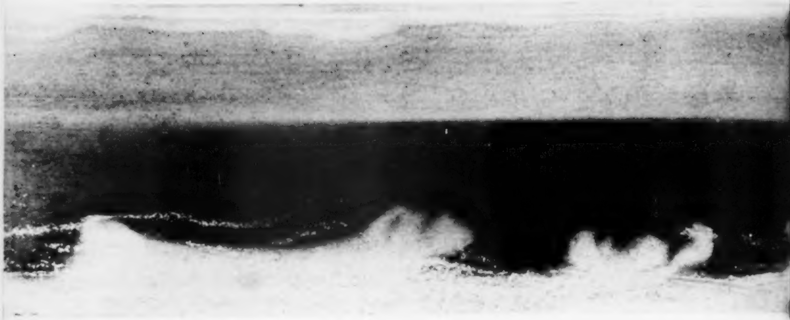
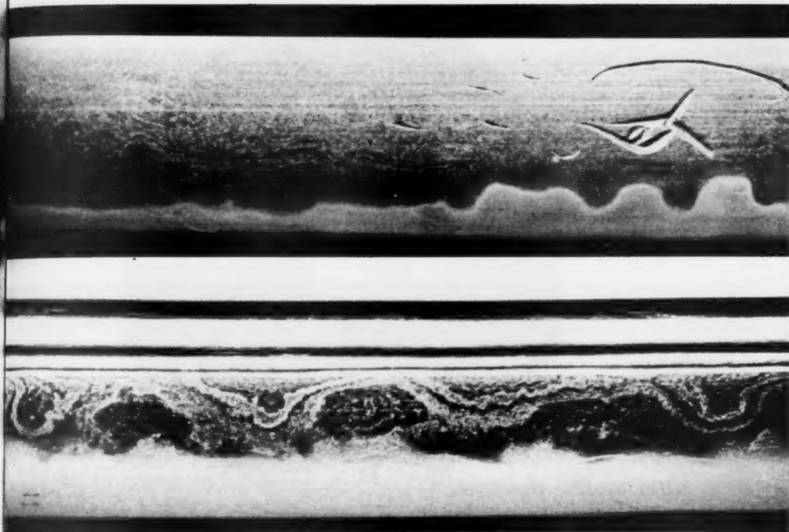


FIG. 6.—*Japanese sword blade, sixteenth century. Surface lightly etched to intensify structure. Enlarged 2/1.*

blade body along an irregular line which is mechanically stronger than a sharp, straight line would be. The fine streaks, resembling spray, are composed of many tiny half-millimeter spots, each a single crystalline grain of the hard form of steel known as martensite, imbedded in the softer matrix. The whole pattern resulted from critical local variations in the rate of cooling when the red-hot blade was quenched in water to harden it.

The main outline of the *yakiba* was produced by the application of a partial protective coat of clay mixed with other materials, sculptured to give the desired contour to the unprotected zone which would later become hard. Some details, however, came from layers of different steels incorporated in forging and then sectioned at locally varying angles when the blade was finally shaved and ground to shape. There could be as many as a million layers of steel in one blade, resulting from a precise regimen of repeated folding, welding, and forging out the starting material, coating it each time with a flux of clay,



. 7.—*Details of two fourteenth-century Japanese sword blades with standard Japanese ish revealing grain and* yakiba. *Oblique illumination, natural size.* (*Photographs by Captain D. E. Craig of blades in his own collection.*)

ashes, and charcoal so as to control the carbon content and remove residual slag from the crude steel simultaneously. The final texture depended on the precise arrangement of the layers of steels with different slag and carbon contents and on the angle at which the final surface cut across them. Sometimes the result, as in Figure 7, was like the grain in a piece of wood.

The details of grain and *yakiba* were revealed on the surface of the finished blade by a careful polishing process. The final effect was not a polish in the usual sense but a fine matte finish produced with abrasive stones and revealing the fine metallurgical texture by slightly differing degrees of light-scattering qualities on metal of different hardness. The effect is subtle and not

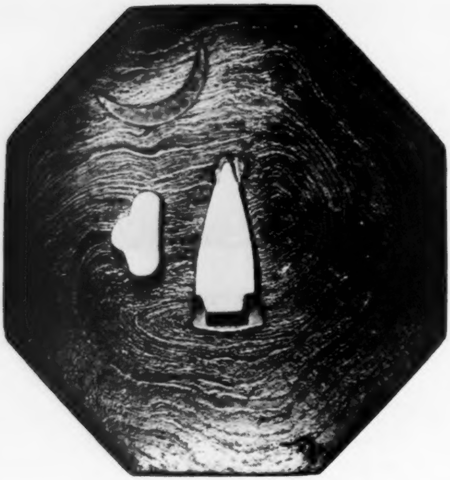


Fig. 8.—*Pair of Japanese sword guards, iron* MOKUME, *inlaid with moon and constellation in silver.* (*Collection of G. E. Hearn.*)

easily apparent to Western eyes, but it was even more admired by the Japanese warriors than were the serpents on the Viking swords by their users.

In a country where materials like rough stone, wood, and jade have always been valued for their textures, it was natural that the textures of metals would also be found and used. The Japanese developed copper and silver alloys whose sole justification was that they could be given a pretty patina. They also developed the art of making wood-grain patterns in forged nonhomogeneous metals, finished by deep etching. These were used chiefly in sword guards that were the apex of masculine jewelry. One of these is shown in Figure 8. The whole decoration results from the flow lines of the forged metal, revealed by etching.

The Japanese techniques remained unknown in Europe until it was too late for them to be of more than antiquarian and aesthetic interest. The fame of the Damascus sword, however, was spread by returning Crusaders, and many European metallurgists later made efforts to duplicate it. None of them had any success until 1823, when Bréant, an employee of the Paris mint, found that the Damascus "water" came from high-carbon steel, melted and cooled slowly, and then forged in such a way that its crystalline segregation pattern would not be lost as a result of too high temperature or too extensive an elongation in any one direction. Bréant was able to solve the problem where his predecessors failed because he had the advantage of two then new theoretical discoveries: the recognition that carbon was the principal effective element in steel and the formulation of laws of chemical combination. Factories for manufacture of Damascus blades were set up in France and Russia, but the still newer steel-making methods of Bessemer and Siemens, and particularly the improved methods of composition control and heat treatment of lower carbon steel,

prevented Bréant's discovery from becoming economically important.

DAMASCUS GUN BARRELS

Decades earlier, however, another kind of oriental textured metal had an even greater effect on European metallurgy. In this case the influence came from gun barrels that also bore the name of Damascus, although they had nothing in common with the swords except the name of the city where Europeans first encountered them. Actually, neither was manufactured in Damascus: the best of the swords were made in Persia from Indian steel, and the gun barrels came from India or Turkey.

The Damascus barrels were made by welding strips of iron and steel together, twisting, flattening, and coiling the metal in a helix to form the barrel—a method reminiscent of that used for the Merovingian-Viking blades. These barrels were much stronger than those made of a simply forged edge-welded strip and could be identified by the surface pattern that was developed on the finished surface by etching, as in Figure 9. The secret of their manufacture was easy to guess, however, and production was begun in various European countries in the eighteenth century. This led to a remarkable chain of scientific events.

It began in 1773, when Wässtrom, who had established a factory in Sweden, gave a detailed description of the process at a meeting of the Swedish Academy of Sciences. His remarks on etching caught the interest of a metallurgist named Rinman who was in the audience, and the latter immediately made a thorough investigation of the effect of acids on different kinds of iron and steel. Rinman was the first to show that it was the presence of some "plumbago-like" material [actually graphite or iron carbide], remaining after solution of the metals, which distinguished the various kinds of steel and cast iron from each

Fig. 9.—*Detail of barrel of a Turkish carbine, eighteenth century. Enlarged 2/1. (Victoria and Albert Museum.)*

other and from wrought iron. Rinman's observation then was picked up by his countryman, the famous chemist Bergman, who did quantitative studies of the amounts in various steels and iron of what he called "phlogiston," in line with the chemical terminology of his time. Bergman's work in turn paved the way for a famous paper in 1786, by the French scientists Vandermonde, Berthollet, and Monge, in which the role of carbon was definitely described.

This was the beginning of the chemical revolution, and in the nineteenth century, with the introduction of chemical control of raw materials and impurities, metallurgy flourished in scale, in economy, and in quality. A real science of metals, however, still had to wait for an understanding of structure as well as composition. The Swedish and French chemists had seen the carbonaceous residues that remained when steel was completely disintegrated by acid; it was left to an Englishman

to develop a technique by which carbon and carbides could be seen *in situ*. And his work in turn grew out of the use of etching by an Austrian museum curator.

Most early uses of etching depended either on uniform attack, as in armor or plates for intaglio printing, or on differences in composition shown up by differing rates of attack, as in the Damascus steels. No crystallinity was revealed, in part because it was a subtle effect at best and in part because the crystals were too small to be easily seen. For a brief period after 1814 decorative metal trinkets were made in France from tin plate that had been etched after it had been heat-treated to develop good crystals, often with special patterns produced by tricks of local heating or cooling. A similar structure can be seen today on the inside of any tin can that has contained fruit, although its aesthetic qualities are not appreciated now. But, slightly earlier than this, crystallization patterns had been developed in the one case where a chemical difference accompanied crystallinity on a scale large enough to be seen easily with the naked eye—in an iron meteorite. This is probably the earliest useful result to have come from space research.

Alois von Widmanstätten, curator of a meteorite collection in Vienna, discovered the pattern in 1808 in a meteorite that he was treating with nitric acid. In 1815, in collaboration with Von Schreibers, he produced some beautiful typographic reproductions of the structure by inking the etched surface and pressing it directly onto paper, giving impressions with superb detail. One of them is shown in Figure 10.

This process, later called "nature-printing," was important in the days before photoengraving, for it bypassed the sometimes misinterpreting eye of the artist and engraver. It had previously been used to depict the details of plants in botanical books, but Widmanstätten was the first to use the technique on inorganic matter. It was later used in the Austrian State Printing

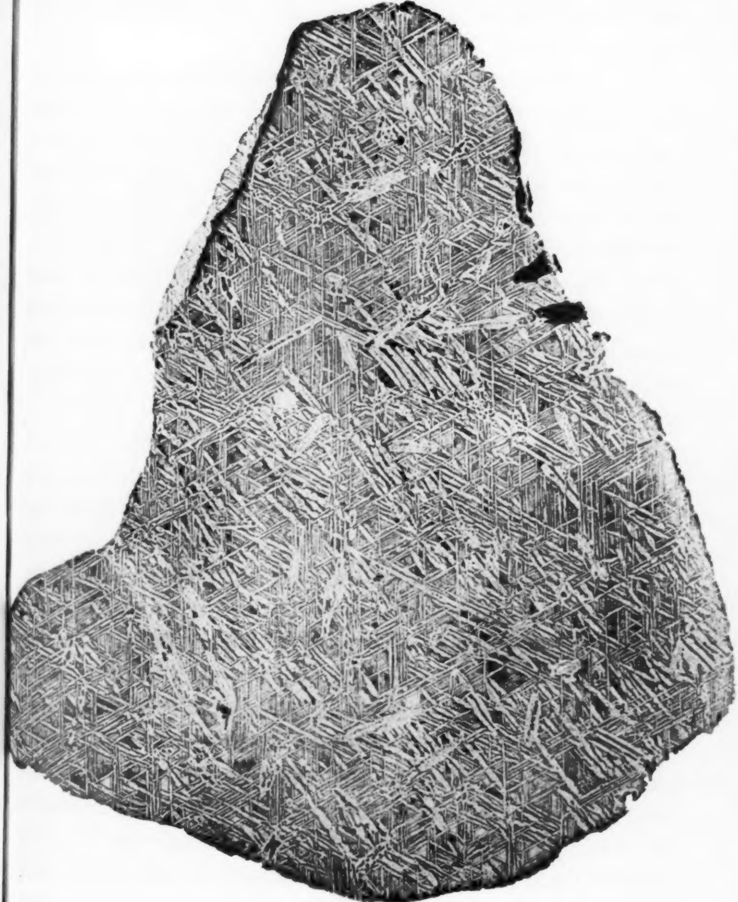


FIG. 10.—*Typographic impression from the surface of an etched meteorite made by Widmanstätten and Schreibers in 1815. Slightly reduced.*

Works in the 1840's and 1850's with excellent results but was soon after displaced by the cheaper and more versatile photoengraving process.

The Austrian studies of meteorites eventually also came to the attention of Henry Clifton Sorby, a microscopist in the English steel-making center of Sheffield. Sorby was a man of independent means who worked at his home on scientific problems of whatever kind happened to interest him—an amateur scientist in the true sense of the word, and a very gifted one. He was the first to stain biological samples with dyes in order to differentiate tissues, and he had previously distinguished himself by establishing the scientific study of rocks based on methods of examining thin sections of rock under the polarizing microscope.

His geological studies led him naturally to meteorites, and from iron meteorites he went on to artificial iron and steel. He tried Von Widmanstätten's technique of chemical etching and direct printing at first, but he soon progressed to higher magnifications. He was active in the Sheffield Literary and Philosophical Society, a typical nineteenth-century group that had evening meetings on many topics, and from brief entries in Sorby's diary in the summer of 1863 it seems likely that his first attempts to apply microscopic techniques to artificial metals were inspired by conversations with a friend who was preparing a paper for the Society on the refining of steel. In any case, in 1864, with a professional photographer, he produced a set of historic photomicrographs. One of these, reproduced in Figure 11, shows crystalline iron carbide as a network around iron-rich crystals in a piece of blister steel made in Sorby's home city of Sheffield.

Thus, two centuries after Robert Hooke had discovered the cells of plants under the microscope, Sorby became the first man to see the true microstructure of a metal. In the centuries

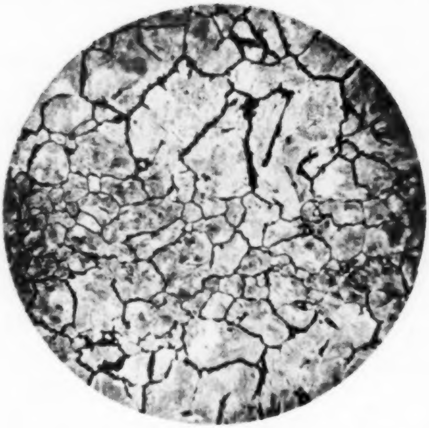


FIG. 11.—*Photomicrograph made by Henry Sorby in 1864. Blister steel, etched. Magnified ×9.*

before him some early European microscopists had looked at metals, but they could see only scratches or irregular deformities and soon turned to biological objects whose shape and internal structures were more easily visible. Even if they had looked at a piece of armor or an artist's bitten plate—the only etched metals then available—they would have seen little, for such etching was too deep to show significant structure. In Sorby's time the factors needed had all become available, and it is certain that someone within the next two decades would have studied the structure of metals under the microscope. The first significant experiments took place when and where they did, however, because of the unique combination of Sorby's intellectual curiosity, his personal contacts in the steel-

making center of Sheffield, and his leisure to work out the problems that he chose because he was not pressed by urgent day-to-day problems of production.

Sorby's discoveries, unfortunately, were not published in full, and his technique lay dormant until it was picked up in Germany and France twenty years later. After 1885 there was an extremely fertile period when structures were observed under all kinds of conditions. Then, in 1900, the mass of observations that had accumulated were suddenly put in order by the application to them by the Dutchman Roozeboom of Willard Gibbs's phase rule, which relates the number of distinct forms coexisting in a chemical system to the variables of composition, temperature, and pressure.

It is interesting that simple, easy-to-understand structures like copper and lead were studied very little, while the extremely complex and economically important alloy, steel, was studied intensively. Most important was the work that revealed the relation between the structure of steel and its composition (its carbon content) on the one hand, and the temperature of its heat treatment on the other. This would have been impossible without the separate development of good techniques for chemical analysis and for the measurement of temperature. Osmond, a Frenchman, in the last decades of the nineteenth century developed and used methods for systematically measuring effects that had been qualitatively recognized by generations of practical tool-makers, and he related these to the newly observed microstructures. Russian and Spanish metallurgists of the same period made new discoveries by using the pyrometer [an instrument for measuring temperatures] along with acute observation of changing details of fracture and of the stains produced by acids acting on the surface of steels quenched from various temperatures.

Early in the present century Tamman and his students in

Germany used microscopy and thermal analysis together to map the constitution of hosts of alloy series, following principles that had been developed in France and England. The next great period came when the introduction of X-ray diffraction in 1911 made it possible to learn about the arrangement of atoms in crystal lattices. Now, in 1960, we are well into a third phase, when advanced electron-microscopic techniques have made it possible to see the distribution of imperfections in crystals. At last, theory, experiment, and observation combined have given us a picture of the microcrystal in metal, with the properties of metals depending directly on the sizes, configurations, and compositions of different kinds of crystal.

Philosophers as well as scientists over the centuries have helped to build up the understanding of the nature of matter that we have today. The mechanical corpuscular philosophy that inspired Réaumur grew out of a revival of interest in Greek atomism and led in turn, after long stagnation, to the atomic theory we now know. Most of the properties the corpuscularians tried to explain, however, were not due to the atom but to aggregates of particles on a larger scale: the molecule and the microcrystal.

Unraveling the different levels of structures was a long process. The stacking of spherical parts together to build up crystals, first suggested by Kepler in 1611, was developed by Hooke and Huygens, then revived with polyhedral units (a physical regression but a conceptual help) by the metallurgist Grignon, and became mathematical crystallography with Häuy in 1784. Then Dalton in 1808 set forth his atomic theory, which was essentially a theory of the simple molecule, and so successful was it that for a century chemists' eyes were closed to everything that was not simple. Thus, for a time, most of metallurgy was excluded from the advances in theoretical chemistry, since in metals and alloys the molecule is really the crystal, in which

an infinite variability of composition is often possible. All crystals have imperfections in them which allow diffusion and deformation processes, but these for a time were thought to be impossible because the essence of the concept of crystallinity is rigid regularity.

Nowadays, of course, we realize that both order and disorder are necessary, that both are interesting, and that the very existence of each requires the other. Between the many little crystals in a metal (or in a ceramic or a rock or any microcrystalline material) lies a layer of material, not over two or three atoms thick, so disordered as to be essentially like a liquid. Within crystals there are fluctuations of composition, lattice sites with atoms missing from them, partial planes of extra atoms and various other faults in the uniformity of stacking, together with all degrees of interaction among these diverse imperfections.

It is a complex picture that was slowly arrived at: fracture first showed the existence of some structure; the microscope revealed the crystallinity of all metals; after 1911, X-rays measured the regularity of atomic spacing and hinted at some disorder; more types of disorder were postulated theoretically to account for the ease with which crystalline metals could be deformed plastically, and these were found in models of crystals made from arrays of uniform bubbles before they were found microscopically in very special cases. Now the electron microscope can show the actual spatial arrangement of the imperfections. Much of the present work on metallurgical theory is aimed at providing a quantitative understanding of the energy of these various configurations and their interaction.

The future advance of theory in this area will become slower unless some methods can be developed for dealing with moderately complex things in a definite, communicable, and computable way. Otherwise the knowledge in the fingers of the

practical man will in some way continue to transcend all the science at his disposal; he will retain a kind of feeling for the nature of his materials in their full complexity that will be more real than anything that the theoretical scientist can compute about the interacting behavior of the parts.

The future of science, certainly in this area and perhaps in most others, will turn even more to a consideration of structure, of the interaction of forces with different configurations of matter on different scales; and it may even begin to look a little like art in its concern with interesting, complex, and perhaps not uniquely or rigidly defined relationships.

Are tears and laughter
part of language? Signs?
What is the difference between
"ear-languages" and "eye-languages"?
We stand on the threshold
of a new definition of language,
maintains this French scholar.

recent definitions of language

By Georges Mounin

Definitions are often viewed with a skeptical eye. The most diverse definitions are successfully applied to a given subject; their discrepancies are noted, and conclusions are drawn concerning the vanity of quibbling over words. In the best of cases the writer, before beginning his own exposition, proposes the

definition which he will follow exclusively, convinced that all terminologies are valid so long as they are explicit and respected.

This methodological hygiene is not without merit for discussions among specialists within a previously delimited field, sufficiently described. But, if we consider a series of definitions covering several centuries—those of language, for example—we see that we are not precisely concerned with a history whose possible meaning may be sought. In addition, contemporary logic has familiarized us with the idea that the search for a definition is more than just an urgent academic need. A correct definition, adequate to all that is known on a subject, is both a working tool and a checking device, enabling us to describe better, to classify better, to elaborate better-founded criteria, to delimit our field of study less arbitrarily—in short, to organize our knowledge of things in a way that is more faithful to the nature of things.

Without sketching out a history of the definitions of language, let us take the seventeenth century as an illustrative point of departure. The *Dictionnaire de l'Académie Française* (1694) said merely: "LANGUAGE (*langage*), idiom, tongue that a nation speaks; LANGUAGE (*langue*), terms and manner of speaking of a nation." The *Encyclopédie* [Diderot's *Encyclopedia* (1751–52), which gave birth to the great intellectual movement of the eighteenth century known as the "mouvement des Encyclopédistes"] criticized the definition of Frain du Tremblay [an eighteenth-century author], who criticized that of Furetière's *Dictionnaire* (1704): "Language (*langage*), sequence of words on which each people is agreed; language (*langue*) in use in a Nation to explain to one another what each person thinks." For Du Tremblay it is "a sequence or mass of certain articulated sounds capable of being joined together, which a people uses to signify things and to communi-

cate its thoughts, but which are in themselves indifferent in signifying one thing rather than another." In 1755 the *Encyclopédie* proposes: "A language is the total body of usages proper to a nation to express thoughts by means of the voice."

On the one hand, these definitions mark, unequally, the level the age had reached in its reflection on languages. Furetière is aware of two problems still quite alive: that of modes of speech (*langage*) other than (written) languages (*langues*); "Language," he notes, "is also used figuratively . . . of mute signs; of cries or inarticulate sounds which serve to make known various things") and that of animal communication ("Animals also have their speech [*langage*]," he adds, with some reservation). Du Tremblay attempts to characterize language by its articulated sounds, by their property of "being joined together," and he has a clear intuition, unusual for the time, of the arbitrary nature of the signs; the *Encyclopédie* already contrasts language (speech) to all means of expressing thoughts otherwise than *through the voice*. But, on the other hand, we also feel the weight of the ideology of the time on this last definition. When he defines language as the total *body of usages*, the author is expressing the normative conception of the grammarians of his day. Very explicitly, the whole article establishes the fact that if, "like the Romans long ago and the French today, the nation is one in relation to the government, there can be in the manner of speaking only one legitimate usage"; this differs from the situation in ancient Greece, Germany, and Italy which, divided into governments equal in prestige, have a right to dialects equal in legitimacy. Everything outside this is patois.

A new sounding taken at the beginning of the twentieth century brings up a set of definitions very different from the preceding ones and almost all similar to each other. For Ferdinand de Saussure (1916) "a language is . . . a system of distinct signs

corresponding to distinct ideas." For A. Lalande, in the *Vocabulaire technique et critique de la philosophie* (1926), it is "in the broadest sense, any system of signs capable of serving as a means of communication." For the *Encyclopaedia Britannica* (article by Jespersen) it is "any means at all of communication between living beings." For J. Marouzeau, whose *Lexique de la terminologie linguistique* (1953) registers current usage, it is "any system of signs apt to serve as a means of communication between individuals."

All these definitions show concretely the progress made in a century of comparative linguistics opening the way to general linguistics, a progress which in every statement except one may be summed up by the presence of the word "system." (E. Sapir [1921] speaks at first of a "means of communication," as does Jespersen, but adds: "through the intermediary of a *system* of symbols" [*Le Langage* (Paris: Payot, 1953), p. 16].)

This formulation, in which every writer follows his predecessor almost without modifications from 1916 to 1953, would seem to be evidence of established agreement. The fact is that at any given date it serves to raise as many problems as it solves.

WHERE DO SIGNS FIT IN?

To see language as a means of communication made up of a system of signs was in effect to raise it to the next order: the body of all systems of signs. The linguist who was probably the first to state this definition, Saussure, declared at the same time the necessity of founding a vaster science than that of linguistics, the science of all sign systems: semiology. (Charles S. Peirce, American logician, who died in 1914, had already said: "Signs are employed only in relation to each other, in a system of signs in action ['working system'], never alone." But he was a little-known logician.)

But that was a new problem, which Saussure's definition did not clearly disclose (here we see the instrumental value of a definition); for it really defined every semiological system, implying that every system of signs is called "language," and, consequently, it provided no criterion allowing a distinction to be made between human languages and all other systems of signs or signals, although a difference between them is generally recognized or felt.

There is a historical reason for this state of affairs: at the time Saussure was developing his thought, between 1896 and 1916, very little study was being devoted to means of communication other than natural languages. The International Maritime Code with its flag signals was a rare exception. The study of animal behavior had barely begun. The new logics were still esoteric. In any case, all the definitions which were to replace Saussure's were to stumble over the same obstacle or were, rather, to dodge the issue: if a system of any kind of signs is called "language," everything is language—but then what is the *specific* difference between linguistics, the science of language, and semiology, the science of systems of signs in general?

If, as Joseph Vendryès [contemporary French linguist, who died last year] writes in *Le Langage*, "all organs may serve to create a language"; if, as Giulio Bertoni states in the article *linguaggio* of the *Enciclopedia Italiana*, "human expression is not only articulate and auditive [but] all organs can contribute to the formation of language, which means that we have the language of signs, or mimic language, [if] tears are a language, [if] laughter is a language, etc.," why does linguistics not also study all these systems of signs? Or why was semiology so late in arriving on the scene?

Jespersen, in the article already quoted, groups auditive languages ("ear-languages") and visual languages ("eye-lan-

guages") in the same way. He also admits that there exist "means of animal communication" different from human languages, but he provides no scientific criterion for the specific analysis of these various "systems of signs." He confines himself to stating—and this is the old established clause in the matter—that, "in its developed form, language is indeed a human characteristic, and may be considered as the principle distinctive trait of humanity." Methodologically, we have not escaped from this contradictory situation: every system of signs being a language, and linguistics being the study of language, there is by definition no such thing as semiology, properly speaking; however, since human languages are but one species of sign systems among many ("simply the most important of these systems," says Sausurre), the human languages must then be studied separately from other systems of signs. Or rather: every system of signs utilized by living beings should be called language, and it is therefore possible to speak of animal languages. However, the human languages are systems of signs totally different from all the others (but no one ever states scientifically wherein the difference lies).

In fifty years no one has escaped from these vicious circles, not because we are concerned with a vain dispute on terminology but because the spontaneous "axiomatics" of this linguistic moment provided no adequate criterion for elucidating the specificity, intuitively presumed, of human languages as compared with all other systems of signs. (H. S. Sorensen, in 1958, argues again with Hjelmslev to maintain the old definition of language as "a system of signs" and nothing else in his work *Word-Classes in Modern English* [Copenhagen: G. E. C. Gad], p. 12.)

The clearest innovation concerning definition of language since Saussure has come not from linguistics but from contemporary logic. Ordinary language had been exposed to close

critical analysis in order to obtain an absolutely logical language of mathematics. In part continuing Peirce and in part rediscovering him, the new logics finally reached a careful distinction in language among the relationships of signs with things signified (semantics), of signs with each other (syntax), and of signs with their users (pragmatic). R. Carnap has given the definition most frequently quoted today, stemming from this research: "A language . . . is a system of signs with rules governing their use."

Just as the Saussurian definition could be traced for fifty years, the last quarter-century is marked by the various statements of the logicians' definition. Strangely enough, while the nineteenth-century *Larousse* continued the old seventeenth-century definition ("a language is the idiom of a nation"), that of the twentieth century is one of the first (1931) to transpose into linguistics the Carnapian formula: "Language (*langage*): the body of terms of an idiom and of the rules of its grammar." The *Oxford English Dictionary* likewise notes: "Language: a vocabulary . . . and way of using it." We find this transposition in Charles Morris (1946), who believes he can place on this base one of the first treatises of semiology: languages, to deserve the name, must constitute "a system of interconnected signs, combinable in certain ways and not in others. . . ." (*Signs, Language and Behavior* [New York, 1946], p. 34. On pp. 34 and 36 Morris gives three other versions of the same definition, including: "A plurality of signs subject to restrictions in their combinations.") We find it again in G. A. Miller, who speaks of "a body of symbols and of rules for their use." (G. A. Miller, *Langage et communication*, trans. C. Thomas [Paris: Presses Universitaires de France, 1956].) It is partially stated in G. G. Granger (1957): "A linguistic expression appears to us . . . as a discrete linear (or quasi-linear) sequence of elements drawn from a lexicon first

known by its users, the choices being limited by syntactical rules." (See "Logique, langage et communication," in *Hommage à Bachelard* [Paris: Presses Universitaires de France, 1957].)

It is easy to understand why this definition of the logicians, enjoying the prestige of results obtained in their field (it explained the effectiveness of their earliest axioms and facilitated the construction of new and even more rigorous ones), was a legitimate temptation to semiologists and linguists—at least as a hypothesis to be verified in their own fields. But the results do not measure up to what might have been hoped for.

First of all, it occurs to us that this failure is partially due to the fact that in reality the logicians' definition did not really add anything to Saussure's: the obvious addition ("and rules for their use") merely rendered the meaning of the word *system* more explicit. At most the logicians, for their own needs, distinguished clearly the two periods of their creative procedure: to define signs, then to define the combining rules legitimate to these signs. But besides this, and especially, the logicians' definition allowed no escape from the old vicious circle: speaking of *language* as of "systems of signs" in general, they gave up, to all intents and purposes, any possibility of distinguishing in what the systems of signs might be irreducibly specific. (Only Lalande, in 1932, in the *Nouveau supplément* of his *Vocabulaire* suggests that such a specificity was recognized in the human languages: "The word language," he wrote, "is accidentally and in rare cases applied metaphorically to systems of signs or expressions other than words." But the *Larousse du XX^e^ siècle*, in its new logician's definition of language, significantly added: "any means of expressing ideas.")

The case of Charles Morris is here especially typical, because he proposed explicitly to erect "the science of signs,

be they animal or human, linguistic or non-linguistic, true or false, adequate or inadequate, normal or pathological." Now in spite of this program he is unable to say what makes the specificity of each of the systems of communication he envisages, from natural languages to languages of gesture, to that of deaf-mutes, to written languages, to the plastic arts, music, etc.

Morris is indeed a pioneer; his failure is a first step. But he is justly criticized for skilfully avoiding the problems which offered resistance to his "system of signs." A "semiotician," interested in analyzing the specific traits of the various systems of signs, should have been alerted by these recalcitrant facts. Morris tosses off in six lines the *vocal* or *phonic* character of natural languages (the central problem of human language) by a comparison which is not a reason: "Finally," he says, "we should mention that many people, especially those who are linguists by trade, will protest the fact that we fail to include in our definition of language, the condition that linguistic signs must be vocal. As for us, we see no theoretical need to include this condition: to take it into consideration would be like insisting that houses made of different materials should not all be called houses." On another recalcitrant fact, the clarification (if such be possible) of specific traits which oppose or might oppose animal communication to natural human languages, Morris responds with age-old generalities which can no longer be considered satisfactory: that it is "evident that meaningful processes in man presuppose meaningful processes such as occur in animals, and that the first develop out of the second"; that it is "evident that human behavior in language shows astonishing complexity, a refinement immeasurable with that observed in animals." Despite his more learned terminology, Morris teaches us no more on this point than does Buffon, who two centuries earlier had written: "It

is due to the fact that a language supposes a sequence of thoughts that animals have no language."

Morris thus maintains that language, specifically, human language, should be defined as "a plurality of signs subject to restrictions in their combinations," although, as he notes with some embarrassment, "animal signs may be interconnected, and in such a way that animals may be said to infer; [but] there is no proof that these signs are combined, by the animals producing them, according to the limitations of combinations necessary for the signs to form a linguistic system." Morris had but to examine this thesis in the light of Karl von Frisch's descriptions of communication among bees to raise doubts in his own mind concerning the discriminating value of his definition. Colin Cherry, however, the author of one of the most recent and richest works on these questions, hardly goes beyond Morris even after examining von Frisch's work: no language among the bees because—pure Buffon once again —"no system of organized thought." (Colin Cherry, *On Human Communication* [New York: John Wiley & Sons, 1957]. On communication among bees, he adds—to exclude it from languages—that it is neither developable, flexible, nor universal and that it is relative to the past, never to the future; the first, second, and fourth of these traits might be open to discussion. He states that "only man has the gift of language" without indicating a criterion. Generally, he adheres to Carnap's definition. Intuitively, however, he distinguishes *linguistic systems* [the natural languages] from *pure systems* ["systems freely invented or constructed with signs and numbers"].)

Colin Cherry's work is by no means barren: we wish simply to note here that he too, for want of a good definition of language, fails to provide exhaustive criteria which, allowing a

definition of what is specific to each of the most diverse "systems of signs," would provide a foundation for semiology.

NON-SIGNS IN HUMAN LANGUAGE

The key to these various problems, which have remained unresolved for so long, has recently been provided. This achievement came not from an entirely new definition of language, bursting out in opposition to those which had preceded, but from a series of analyses out of which there developed an original view of language, at first implicit, then made explicit little by little, by very reason of its effectiveness.

The point of departure is doubtless to be found in Louis Hjelmslev. He stressed the point that the linguistic sign is formed by means of a limited number of non-signs (phonemes) and repeated that it was one of the characteristic structural traits of human languages. But it seems to have been André Martinet who first (1949) drew all its consequences from his observation, concerning the definition of the language of men as opposed to other sign systems: this is his theory of the *double articulation* of human language.

The expression "articulate language," whose origin and history merit study, conceals the fact that human language, as a system of signs, is articulated twice. Before there was any science of language, this expression used to designate the groups of sounds produced by the voice in such a way that distinct signs, or words, are recognized. In this first meaning it is the phrase, the statement, that are "articulated," that is, cut into articles or segments, as a crab's claw is said to be "articulated." The statement "The earth is round" is formed of four of these segments (the + earth + is + round), as opposed to the "unarticulated" cries emitted by animals, children before they learn to speak, the sick, madmen, and monsters. But when it is said: "the articulate voice," "articulate," "your

articulation is not clear," the term "articulate" is being used in another sense, with reference to the movements of the vocal organs which, this time, cut the statement into sequences of vowels and consonants, not of words. The statement, "the earth is round," is then phonically constituted of eleven distinct articulations (ð + i + ə: + θ + i + z + r + a + u + n + d). (Note that animal cries, those of moaning patients, madmen, etc., which are called "inarticulate," do present this same sort of articulation.)

This antiquated expression, which confused facts of two orders, has been given its fullest meaning in recent linguistics by an analysis which clearly distinguishes the functional place and meaning of these two types of articulation in the system of signs that is human language. The first articulation cuts the linguistic statement into signs, into units called meaningful, since each one has its own meaning: *grosso modo*, these are the words of the language, following traditional terminology. A second articulation cuts the signs themselves into smaller units than the sign (la = l + a, or two units of this type), these being non-significant units, or phonemes. (A. Martinet, "La double articulation linguistique," in *Travaux du Cercle Linguistique de Copenhague*, V [1949], 30–37. These are eight basic pages, constituting a turning point in contemporary linguistics. See also Martinet's "Arbitraire linguistique et double articulation," in *Cahiers F. de Saussure*, No. 15 [1957], pp. 105–16, eleven pages which complete the preceding.) Since the development of scientific phonetics, and even earlier as we have seen, everyone knew this, but nothing had been drawn from it on the theoretical level. Martinet's contribution lay in seeing that this descriptive trait was specific to human languages and set them apart from all other systems of signs. Linguistics distinguishes between original phonic language and its various *written forms*, some of which (ideographs, hieroglyphics) do not reflect the

second articulation of language, while certain others (alphabetic writing, Morse code, Braille, the deaf-mute's alphabet) transcribe this second articulation. These writings are not systems of signs *sui generis;* they are systems called substitutive of the original phonic language (see E. Buyssens, *Les Langages et le discours* [Brussels, 1943]). Martine thus provided the instrumental criterion of a scientific separation—based on the nature of the things studied—between languages and the other means of communication by signs, between linguistics and semiology.

The criterion of double articulation as a fundamental trait of what language is has proved to be an excellent operational criterion. Pictographic-ideographic writings (from pure hieroglyphics to flag-signals); numerical and symbolic signs employed in mathematics and formalized logics; abbreviations either of recognizable design (the schematic silhouette of a locomotive to indicate a grade crossing) or arbitrary in design (a red disk crossed by a white bar to indicate "Do not enter" at a one-way street); the conventional signs of cartography, of standardized industrial drawing, schemas of all kinds, etc—all these systems of signs have been shown to differ specifically from human language because all of them utilize only the first type of articulation: all cut their messages into meaningful units, never into distinctive non-significant units. And the double articulation of human (phonic, or vocal) language provides the key to the richness and complexity of human languages, with which no other system of signs can be measured on a par. Martinet's analysis clearly shows that a system of signs utilizing only the first sort of articulation would have to multiply infinitely the distinct meaningful units to distinguish the multitude of things signified: the number of totally different signs would be immense. On the other hand, in the case of a system of phonic signs, if each distinct meaningful unit had a distinct

meaningful sign, "the arbitrary character of the sign . . . would soon be sacrificed on the altar of expressivity." Martinet concludes: "The phonemes produced by the second linguistic articulation are thus revealed as the guarantees of the arbitrary nature of the sign," which is the instrument of the prodigious combinatory fertility characteristic of human languages.

The double articulation of the human languages also provides the rational explanation of the differences, so often stated a priori between animal communication and human language. Whether we are concerned with communication among bees, or among crows, Martinet's criterion leads to analyses which are finally effective. Among the bees it will doubtless be shown to contain units of the first articulation, meaningful, expressing in several ways distances and directions—but these units (which we shall treat further) are not divisible exclusively in time: they are also "readable" in space (as "round," for example, or "lively dance"). As for crows, their productions are phonic messages like the human voice. Philippe Gramet's experiments tend to prove that these messages are in fact divisible into units of the second articulation (phonemes) but without any evidence within a statement of meaningful units of the first articulation (or kinds of "words"). In any case, these analyses would suggest that it will be possible, in semiology, to begin a rational classification of widely differing systems of signs: from those of signs readable in space to those of signs read in time; from symbolic means of communication (in which the message reproduces mimes or sketches the thing to be communicated) to means of communication with arbitrary signs in which the smallest unit is the total message, or the meaningful unit, or the non-meaningful unit—all this without counting the means of communication which may, as among the bees, combine several of these systems of semiologically different signs.

Though rich in meaning, the criterion of double articula-

tion—whose career has scarcely begun—has not exhausted the search for a definition of language. Just as, two or three decades ago, everyone leaped upon the logicians' definition, which was expected to work wonders, so today they rush from all sides to embrace the *mathematical theory of communication* of Claude E. Shannon and Warren Weaver [American authors of *The Mathematical Theory of Communication* (Urbana, Ill.: University of Ill. Press, 1949)]. Not that this haste should be criticized: all who are interested in the science of signs foresee that this mathematical theory of the transmission of signals ought to help in the exploration, one step further, of the analysis of language. But up to the present all efforts to apply this theory to linguistics have proved to be partial failures because of the very avidity with which the theory has been embraced. Too often this leads to metaphorical transpositions of the terminology proper to this theory, which are then applied in the field of linguistics. As the theory itself has been called in French, apparently through a faulty translation, a *théorie de l'information*, uses of the term *information* have multiplied (loss of *information*, gain of *information*) where the term *champ sémantique* ("semantic field" or, in English, "area of meaning") had previously been used, without anything being added by the new terminology to our knowledge of the facts. In the same way, people are beginning to speak of "semantic noise" instead of saying "equivocation," "ambiguity," "homonymy"; they even speak of "quantity of information"—exactly as, twenty-five years ago, all terminologies were suddenly invaded by "restricted" and "generalized" relativities. This epidemic of terminological measles will pass, giving way to more serious application.

On one point, at any rate, the new theory has already introduced a new element which has proved very useful in our defining criteria of language. This has been in bringing out in-

sistently the fact that a linguistic message is composed of a *linear* succession of *discrete* signs or, in other words, differential, discontinuous, or digital signs.

Here we may surely recall the categorical page in which Saussure had marked the fundamental importance of the linear (i.e., articulated in a succession of units irreversible in time) character of language and its difference from other systems of signs articulated in space. But the semiological value of Saussure's indication had remained unexploited. It took on new value in the stress laid by the theory of information on this characteristic of language, as shown by its presence in Granger's definition. Granger, however, does not draw out of the statement all that he might: this very trait embarrasses him slightly, as shown in the somewhat regretful feeling of his parenthetical "or quasilinear." He observed in fact that, if one follows his definition "mathematics is not only a language," then "mathematical language" would have several dimensions, since a part of its signs (figures, graphs, material arrangement of signs on the page, matrixes, etc.) are read according to structures articulated in space, like the plastic arts. But for different reasons Granger does not accept the plastic arts as languages, even though they are means of communication, because they do not offer discrete units of meaning. In the same way mathematics, according to him, is not merely a language because its "essential function is not to inform," a most dubious and non-discriminating reason. He fails to see how close he is to one of the great semiological classifications, that suggested by Saussure and formulated—though he, too, failed to draw anything from it—by Colin Cherry: that there are systems of signs which are read in time and others read in space.

The *discrete* character of signs is itself confirmed as a highly discriminating trait. It permits a separation, for reasons based on their very nature, of systems which are articulated in units

of this sort, in discontinuity, from all systems of communication in which a *thing signified* of continuous size (e.g., the increasing breadth of a real river) is represented by a *meaningful thing* which symbolizes this continuous size as continuing: the blue line on the map, gradually widening between the source of the river and its mouth. (This example should not be considered as a very special case: let the reader recall all the graphic representations of the *scale*, where the signifying thing is found to be linked in a rigorously formal manner to continuous values proportional to the thing signified.)

Such is the already established contribution of the theory of information to the definition of language. Neither facile irony nor polemical enjoyment led us to begin by criticizing the imprudent use of its terminology without precautions: we did this rather because so much can be expected from the theory. Up to the present, linguistics has not yet truly assimilated the theory of information. When this has been done, a definition of language will doubtless have to be rewritten. This will probably be possible within a few years, but the time is not yet.

MIDWAY Authors

STANLEY COBB, neuropsychiatrist, physician, physiologist, and author of our article on "Comparative Anatomy of the Aviary Brain," is a remarkable person. A graduate of Harvard and the University of Maryland, he was for thirty years Bullard Professor of Neuropathology at Harvard. His awards and honors are numerous, including the Einstein Medal. His earlier contributions did much to define the neurophysiology of the human nervous system. One notable day he seized a rare opportunity, when it was Circus Day at Children's Hospital. The circus ring being near to the physiology laboratory, he and two other scientists strung out of the window yards and yards of wire and recorded the electrocardiogram and myogram of one unwitting and happily performing elephant. He is also a former editor of the *American Journal of Psychiatry*. He still teaches, but carries a lighter load, and turns to the more leisurely pursuit of his old interests, including an early love, the bird. His article is reprinted from *Perspectives in Biology and Medicine*, Spring, 1960.

WESTON LA BARRE is professor of anthropology at Duke University. With degrees from Princeton and Yale, besides teaching at several universities, he has been a research intern at the Menninger Clinic, a Guggenheim Fellow, and has done field work in several continents. During the war he worked for WRA and was a naval officer in ONI and in OSS, serving in China, India, Ceylon, and the West Indies. His numerous publications include studies in several areas of the social sciences. He was awarded the Géza Roheim Memorial Award for distinguished contributions to psychoanalysis and the social sciences in 1958. The article which appears here is taken from his book, *The Human Animal*, published by the University of Chicago Press in 1954 and in a Phoenix paperback in 1960.

FRANCIS LIEBER, author of "In America All Women Are Ladies," was born in Berlin, Germany, in 1800. He emigrated to the United States in 1827, where he was engaged, first in Boston and then in Philadelphia, in teaching and literary activities. In 1835 he was appointed to a profes-

sorship in history and government at South Carolina College, where he remained until he was called to Columbia in 1857. He was a prolific author. Though most of his books deal with history, politics, and political theory, there were many others, including *The Stranger in America*, a work dealing with a voyage through New York State, after he had been in the United States for eight years. From this book, Warren S. Tryon chose the excerpt which appears here to be included in a series of sketches on life in America, 1790–1870, which was published by the University of Chicago Press in book form under the title *A Mirror for Americans* and in Phoenix paperback edition (1961), under the title *My Native Land.*

RICHARD MCKEON and N. A. NIKAM together prepared the new edition of *The Edicts of Asoka*, which the University of Chicago Press published in book form in 1959. We have condensed the Introduction a little, and reprinted a few of the Edicts, for the benefit of our readers. McKeon is professor of philosophy and Greek at the University of Chicago, currently on leave of absence at the Center for Advanced Study of the Behaviorial Sciences, Palo Alto, California. He has been to India twice, once to direct a UNESCO seminar and once to advise concerning philosophy and general education. Nikam is vice-chancellor of the Mysore University, India, and secretary-general of the Indian Philosophical Congress.

GEORGES MOUNIN, trained in the field of Italian literature and language, and professor at the École Normale, is at present assigned to the Centre National de la Recherche Scientifique and concentrates on the problems of general linguistics and contemporary semiology. He has written studies on Petrarch, Dante, and the Franciscan poets and books on *Machiavelli* (1958) and *Savonarola* (1960) and has moved from literary criticism of the modern poets, *Avez-vous lu Char* (1946), to the problems of translations, *Les Belles infidèles* (1955). His concern in this issue is with the definitions of languages and is reprinted from *Diogenes*, Fall, 1960.

CYRIL STANLEY SMITH is Institute Professor at Massachusetts Institute of Technology, a post he assumed last month. Prior to that he was professor of metallurgy and former director of the Institute for the Study of Metals, University of Chicago. He is the author of numerous papers on the structure of metals; the editor of Anneliese Sisco's translation of Réaumur's *Memoirs of Steel and Iron;* and the translator, with others, of the *Pirotechnia* of Vannoccio Biringuccio and Lazarus Ercker's *Trea-*

tise on Ores and Assaying. The article which appears here is a condensation from his book, *A History of Metallography*, published in 1960 by the University of Chicago Press.

. . . with apologies, we correct an oversight. In the last issue we neglected to include the biographical sketch of the author of "Lessons from Abroad for American Management." We present it now.

CHARLES A. MYERS is professor of industrial relations and director of the Industrial Relations Section, Department of Economics and Social Science, at Massachusetts Institute of Technology. He has held many government advisory posts, including those of consultant to the Secretary of Labor in 1958–59 and member of the business-education advisory board, Committee for Economic Development, 1959. Among his many published works the latest is *Industrialism and Industrial Man: The Problems of Labor and Management in Economic Growth*, written with Clark Kerr, John T. Dunlop, and Frederick H. Harbison (Harvard University Press, 1960). The article which appears here is taken from the *Journal of Business*, January, 1960.

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